Appendix A

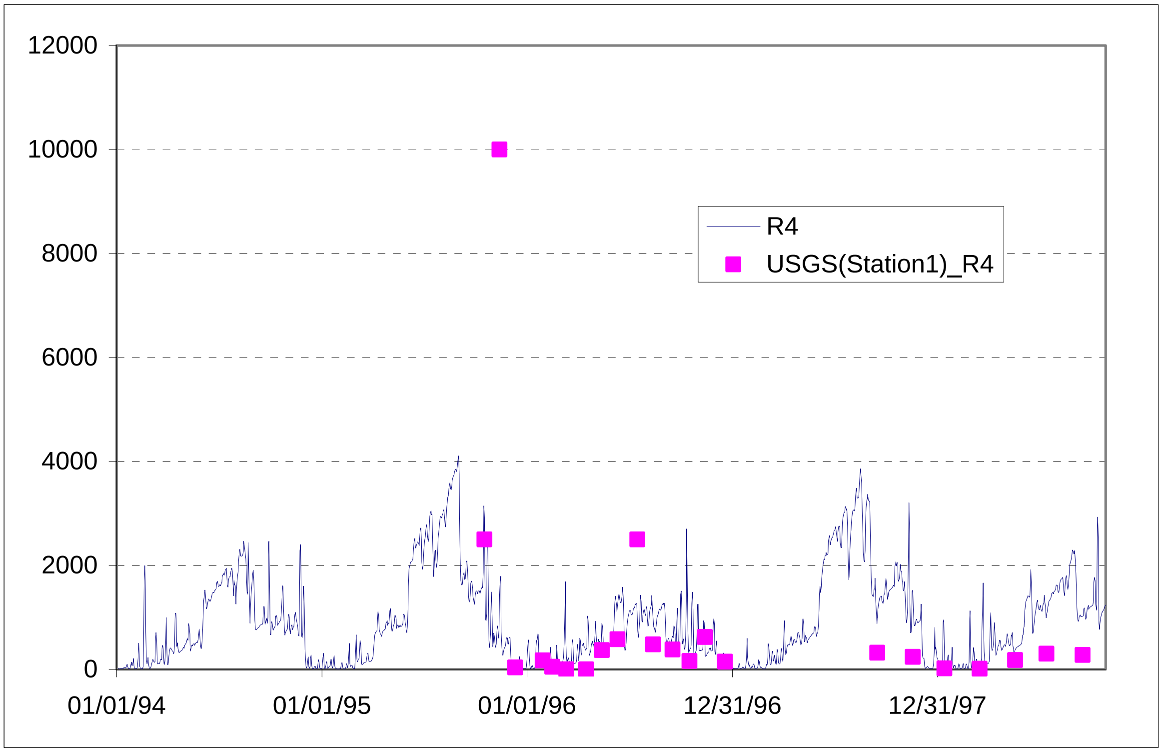
HSPF Model

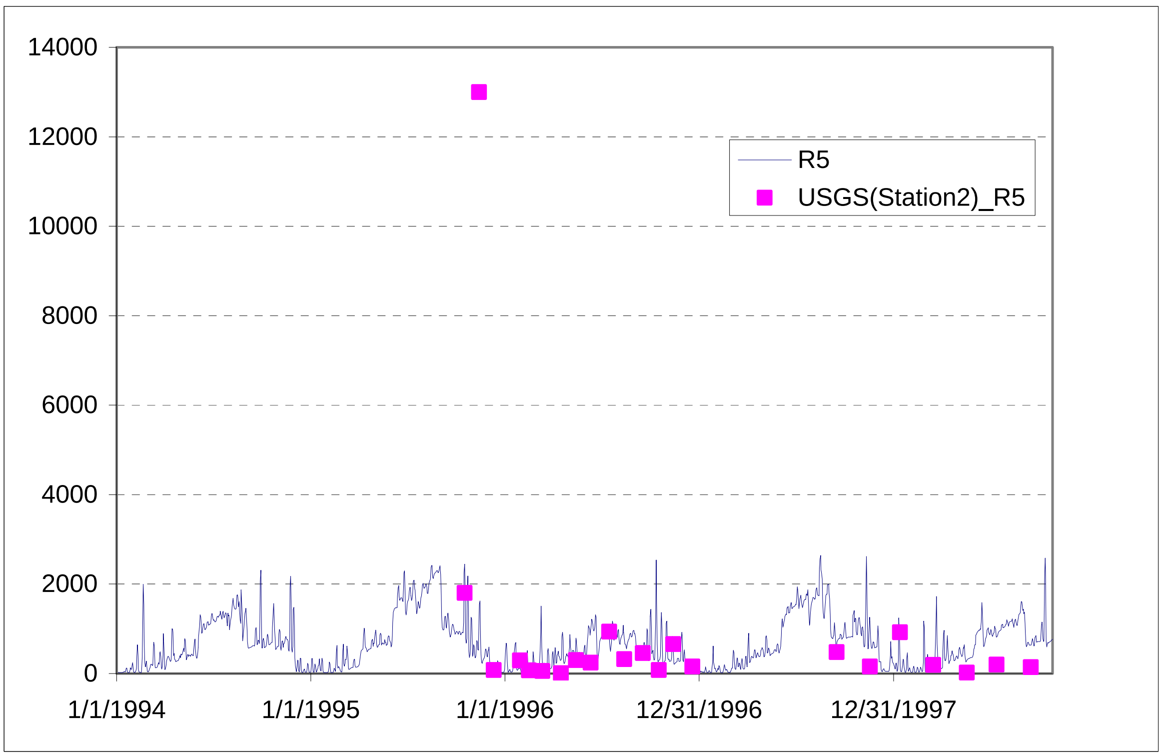
Enterococci Bacteria Simulation

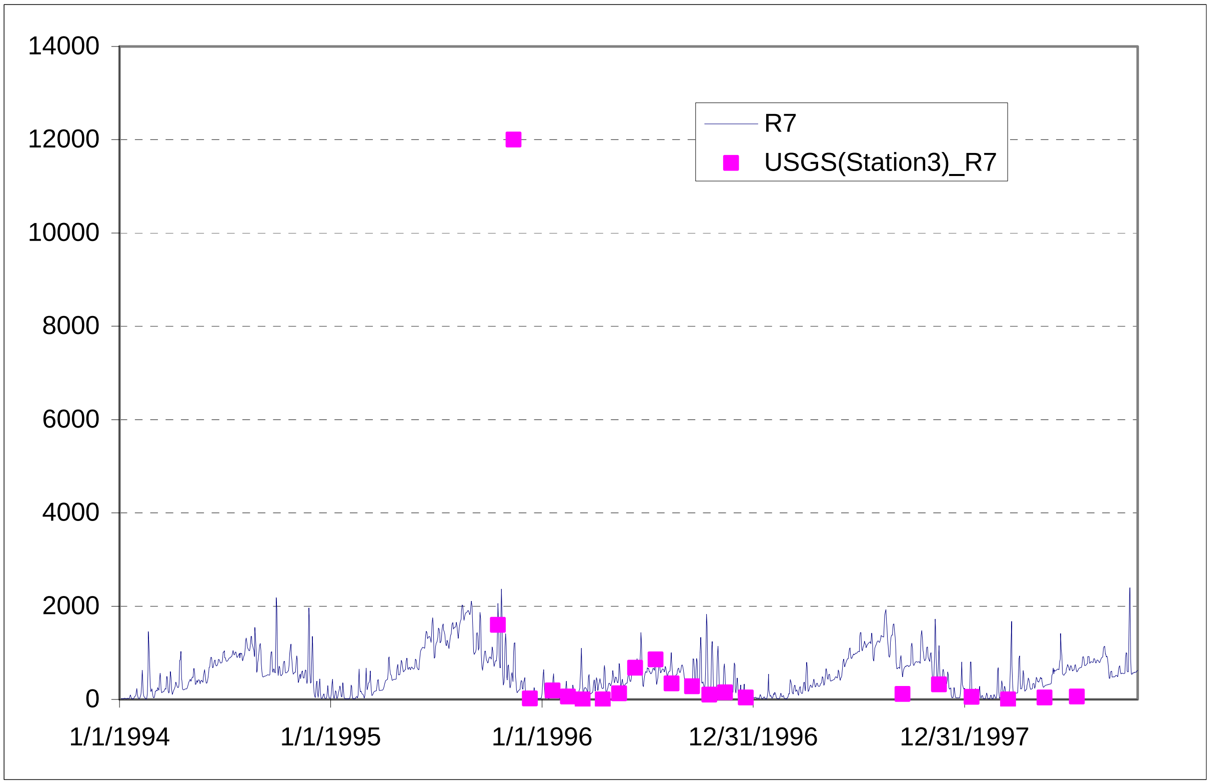
Time-series Calibration Results
(01/01/1994 to 10/29/1998)

Brandywine Creek Watershed

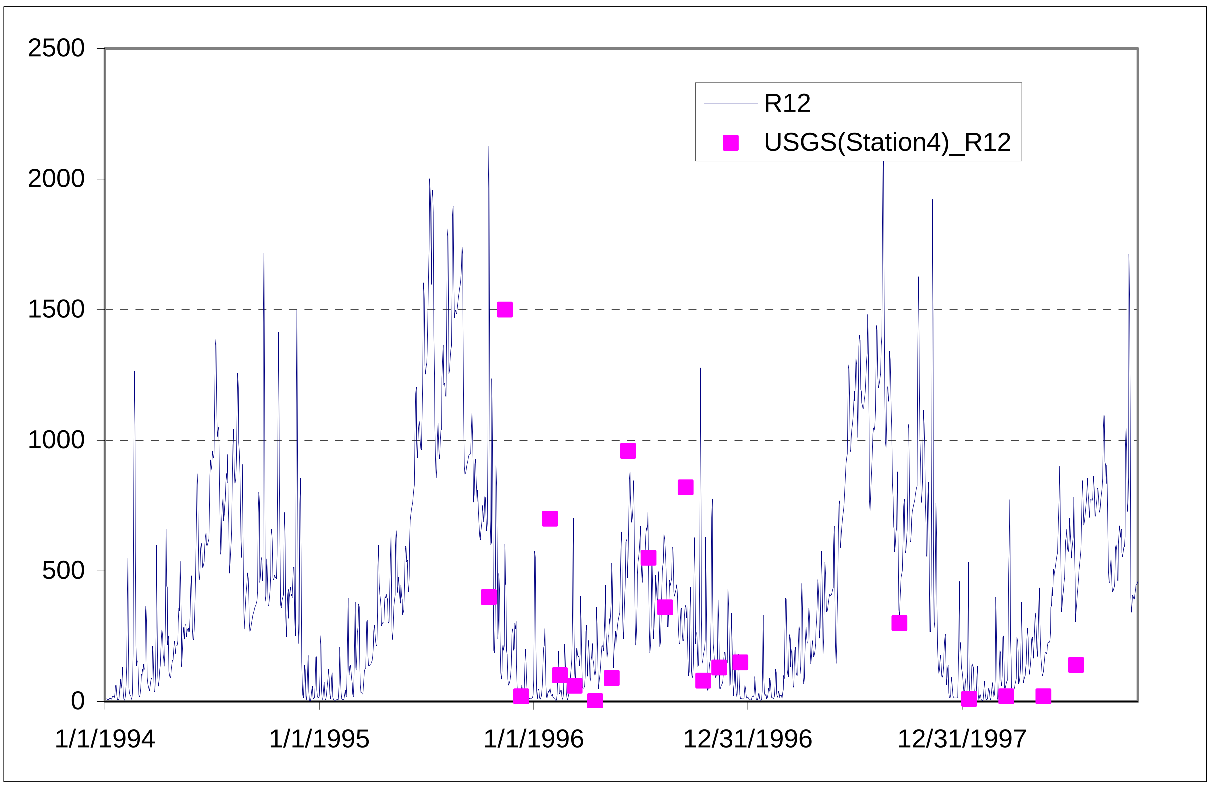
(y-axis units are cfu/100 mL)


12000
10000
8000
6000
4000
2000
0
01/01/94
01/01/95
01/01/96
12/31/96
12/31/97
R4
USGS(Station1)_R4

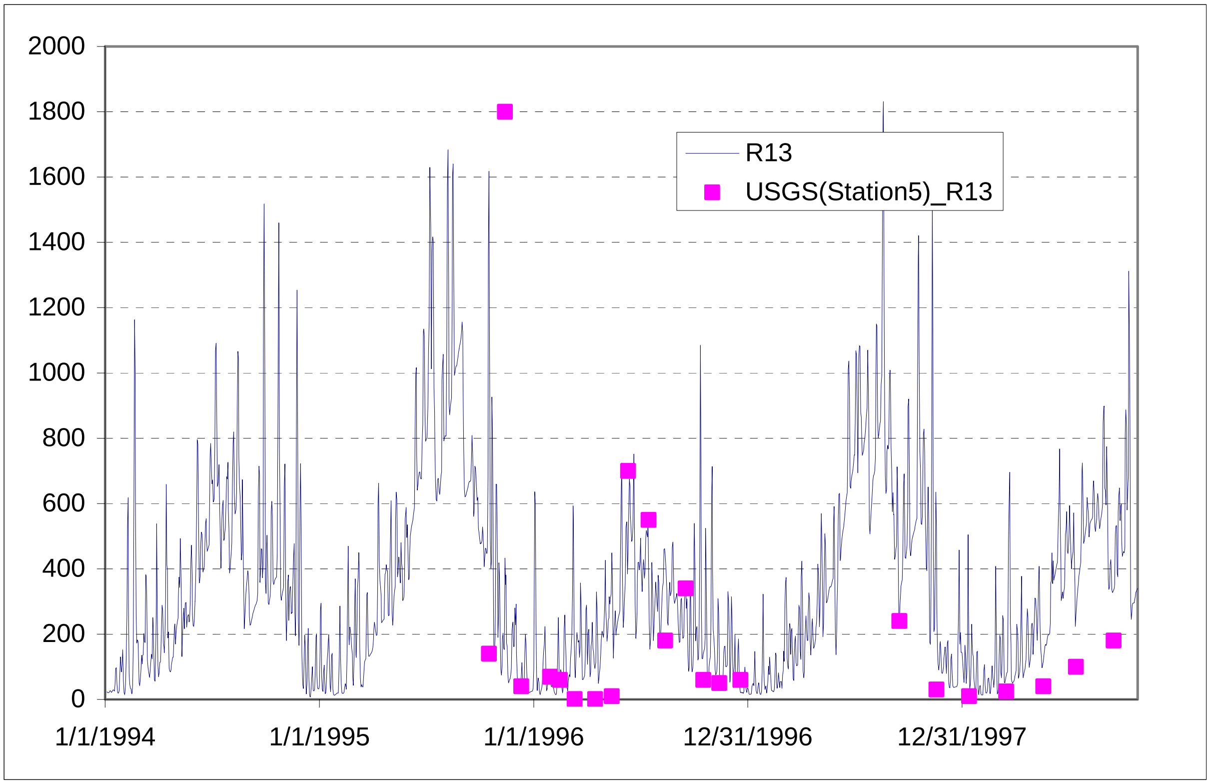

14000
12000
10000
8000
6000
4000
2000
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
R5
USGS(Station2)_R5

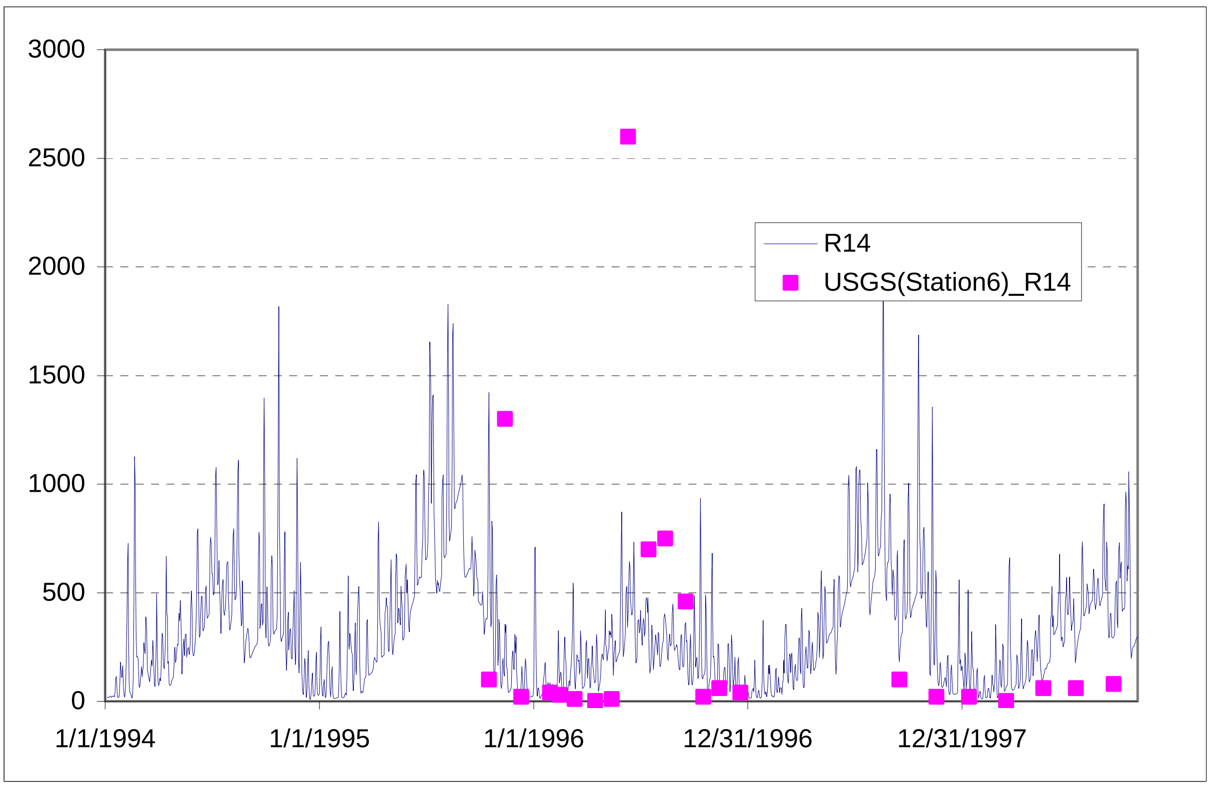


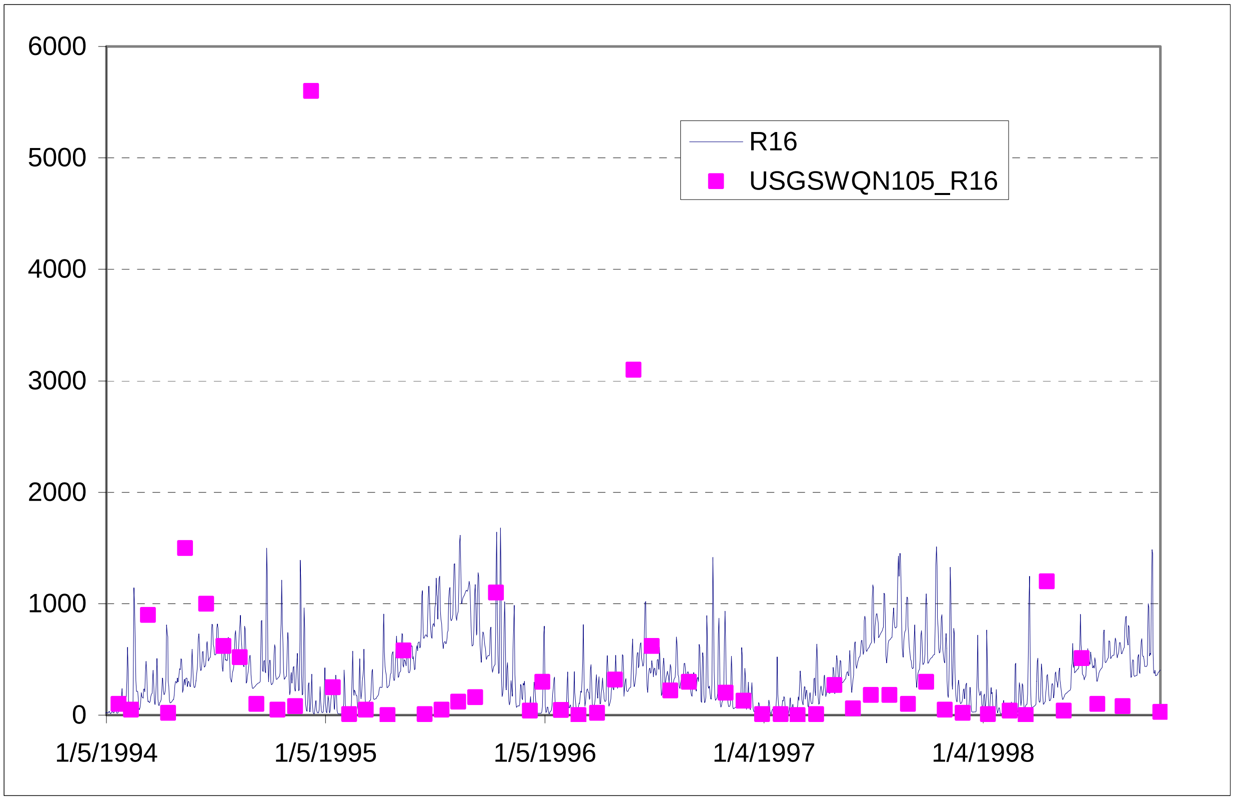
14000
12000
10000
8000
6000
4000
2000
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
R7
USGS(Station3)_R7

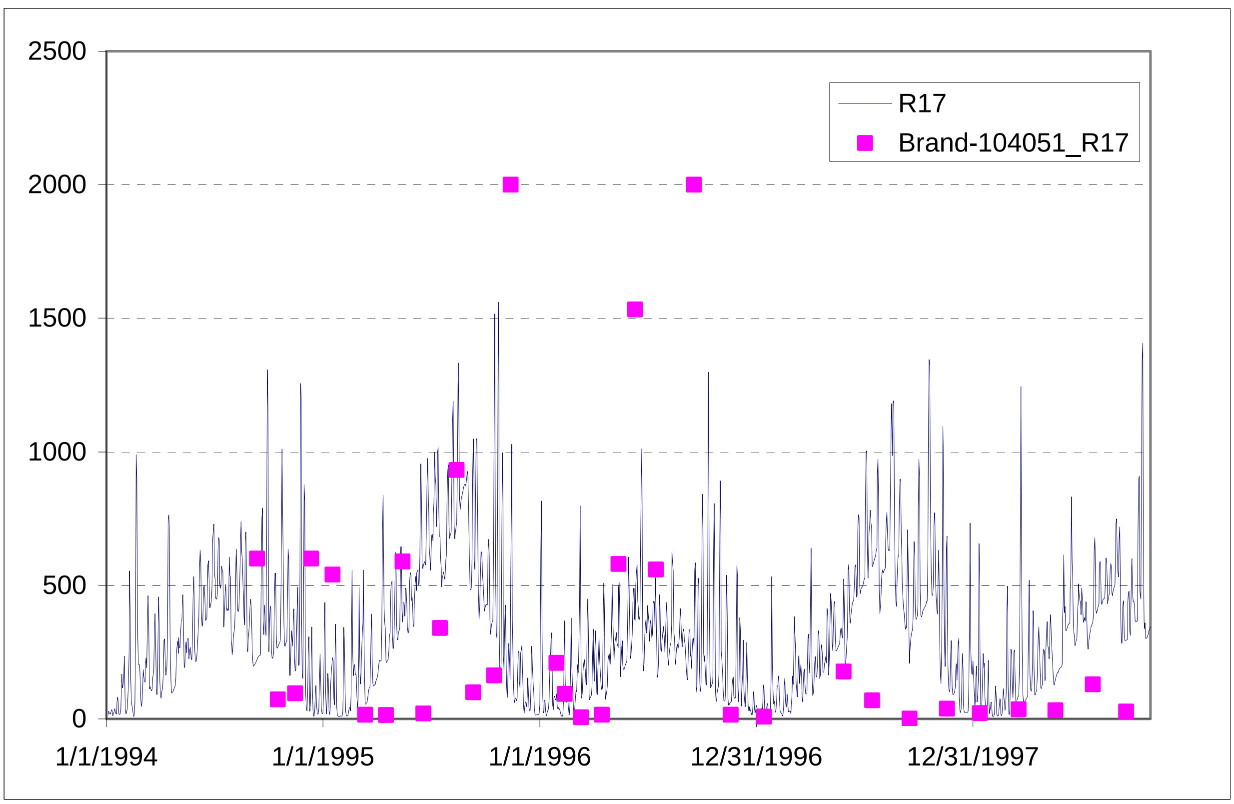


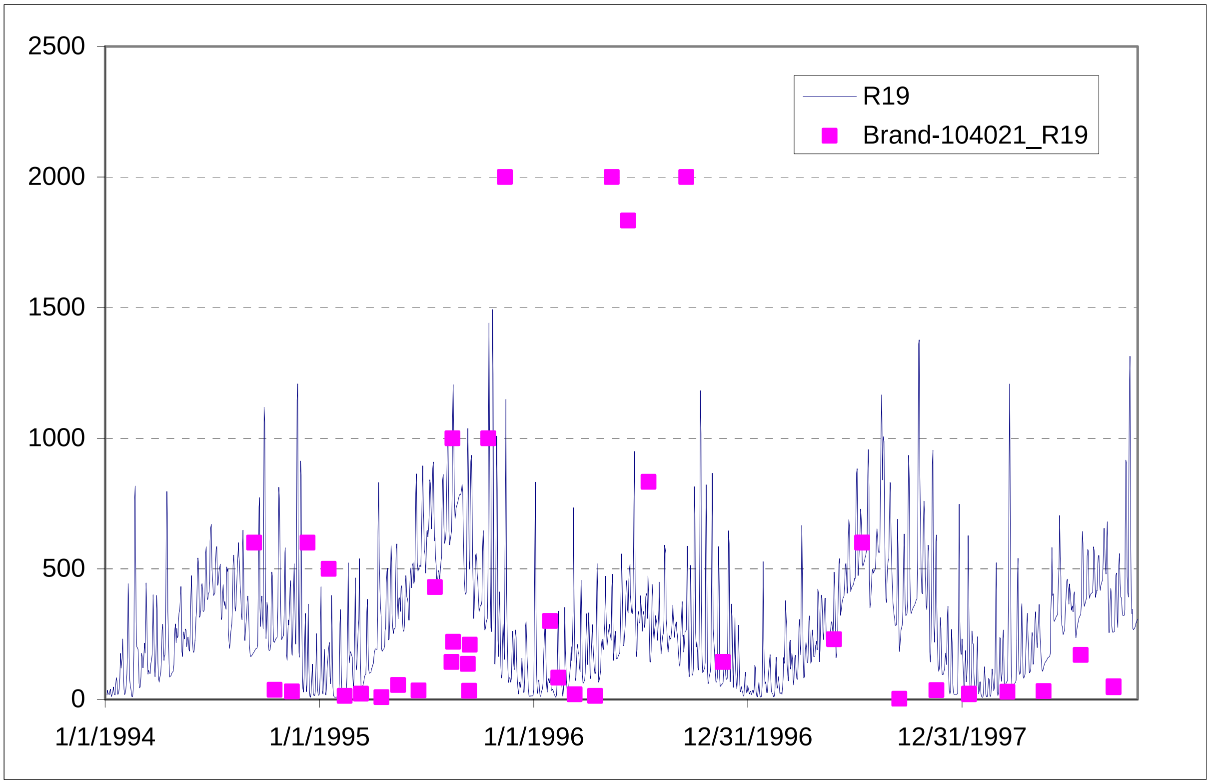
2500
2000
1500
1000
500
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
R12
USGS(Station4)_R12

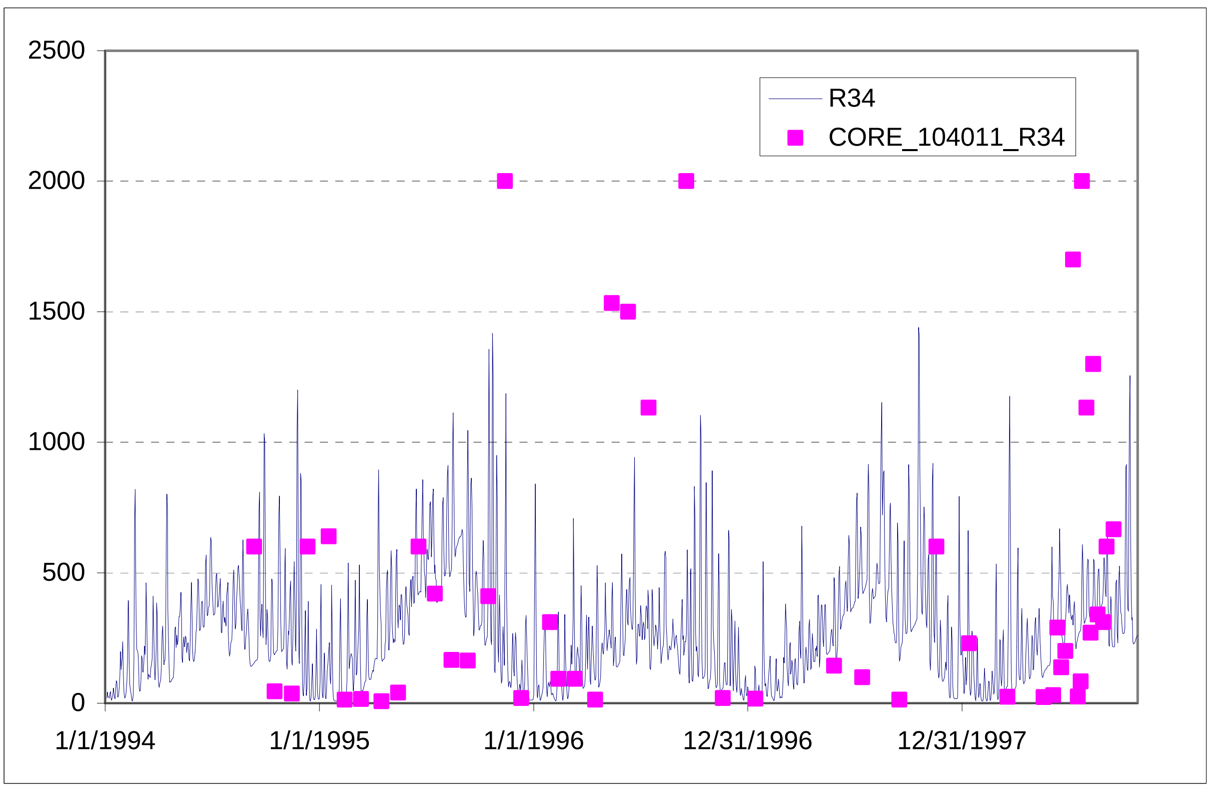

2000
1800
1600
1400
1200
1000
800
600
400
200
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
R13
USGS(Station5)_R13


3000
2500
2000
1500
1000
500
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
R14
USGS(Station6)_R14


6000
5000
4000
3000
2000
1000
0
1/5/1994
1/5/1995
1/5/1996
1/4/1997
1/4/1998
R16
USGSWQN105_R16


2500
2000
1500
1000
500
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
R17
Brand-104051_R17


2500
2000
1500
1000
500
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
R19
Brand-104021_R19


2500
2000
1500
1000
500
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
R34
CORE_104011_R34

Appendix B

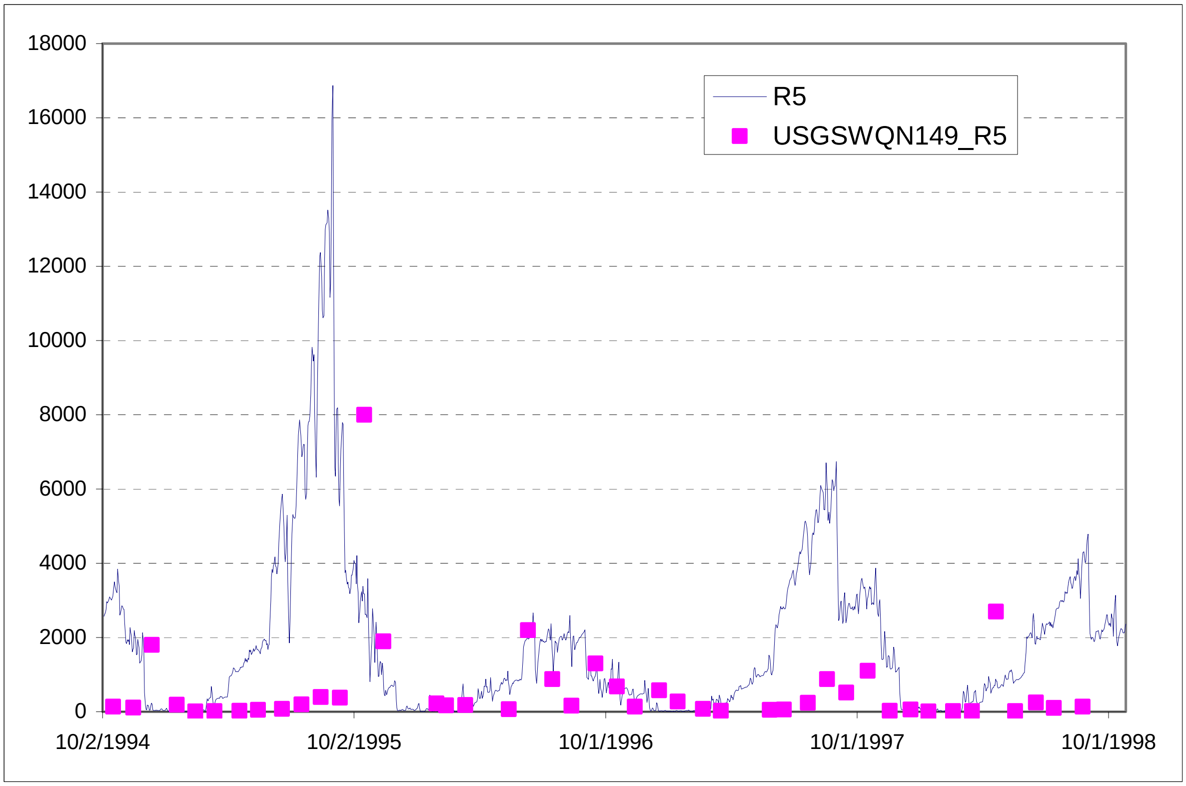
HSPF Model

Enterococci Bacteria Simulation

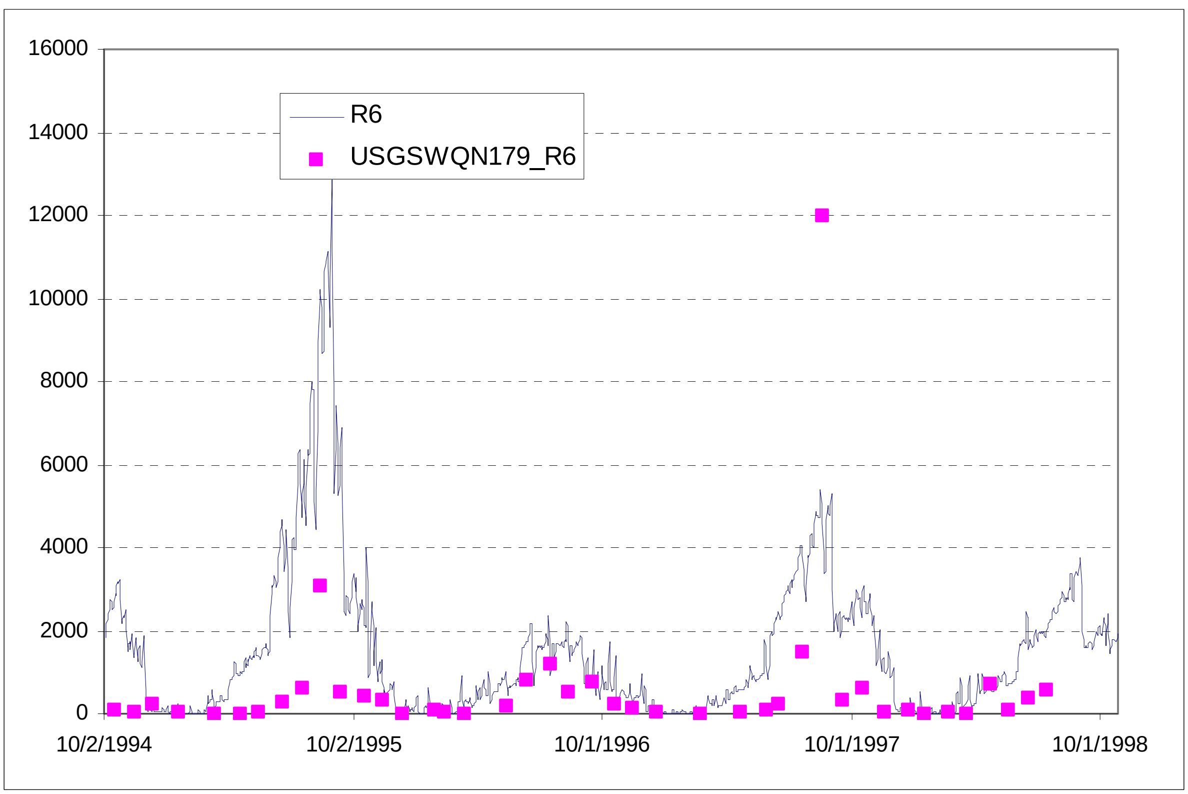
Time-series Calibration Results
(10/1/1994 to 10/29/1998)

White Clay Creek Watershed

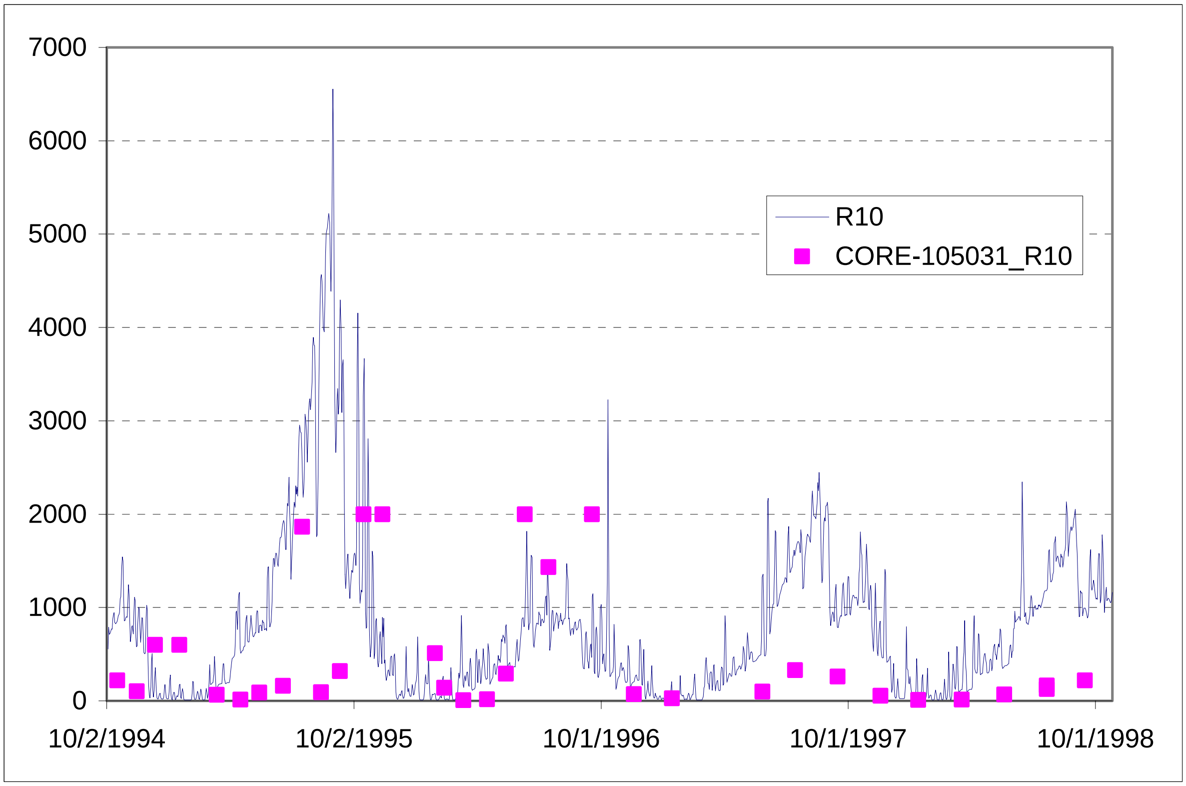
(y-axis units are cfu/100 mL)

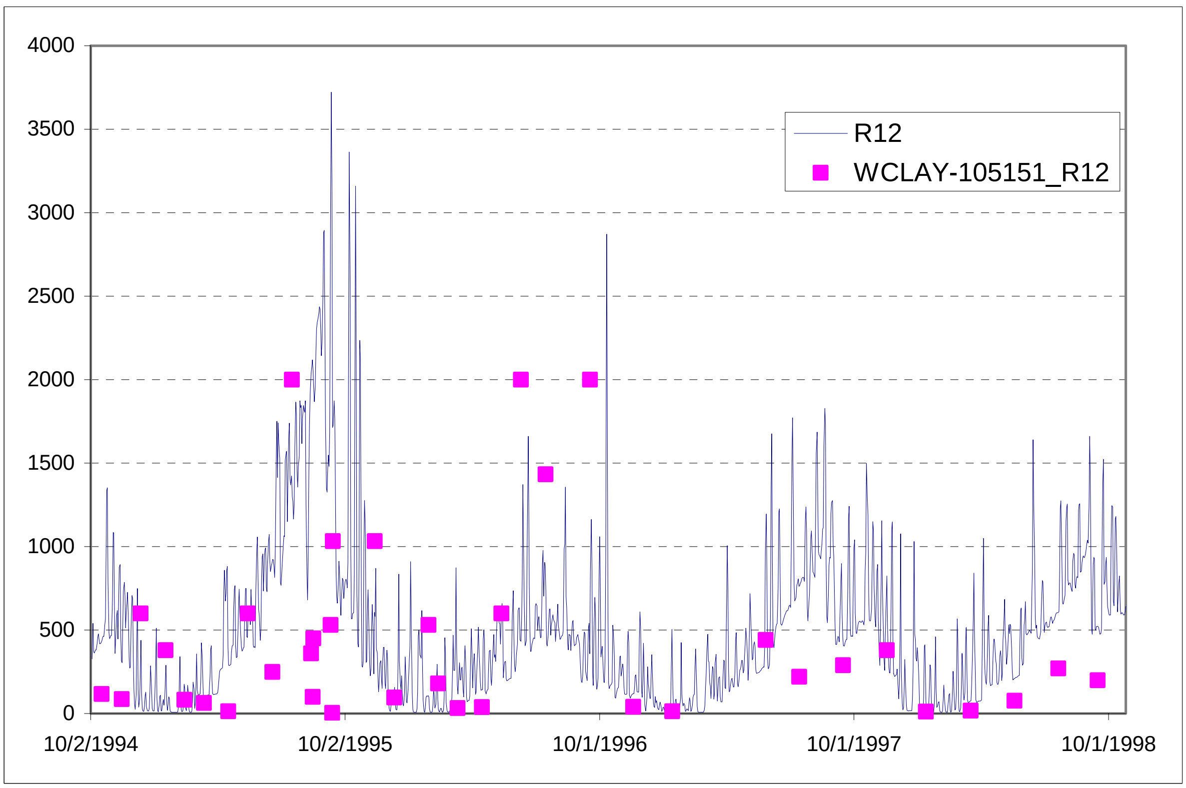


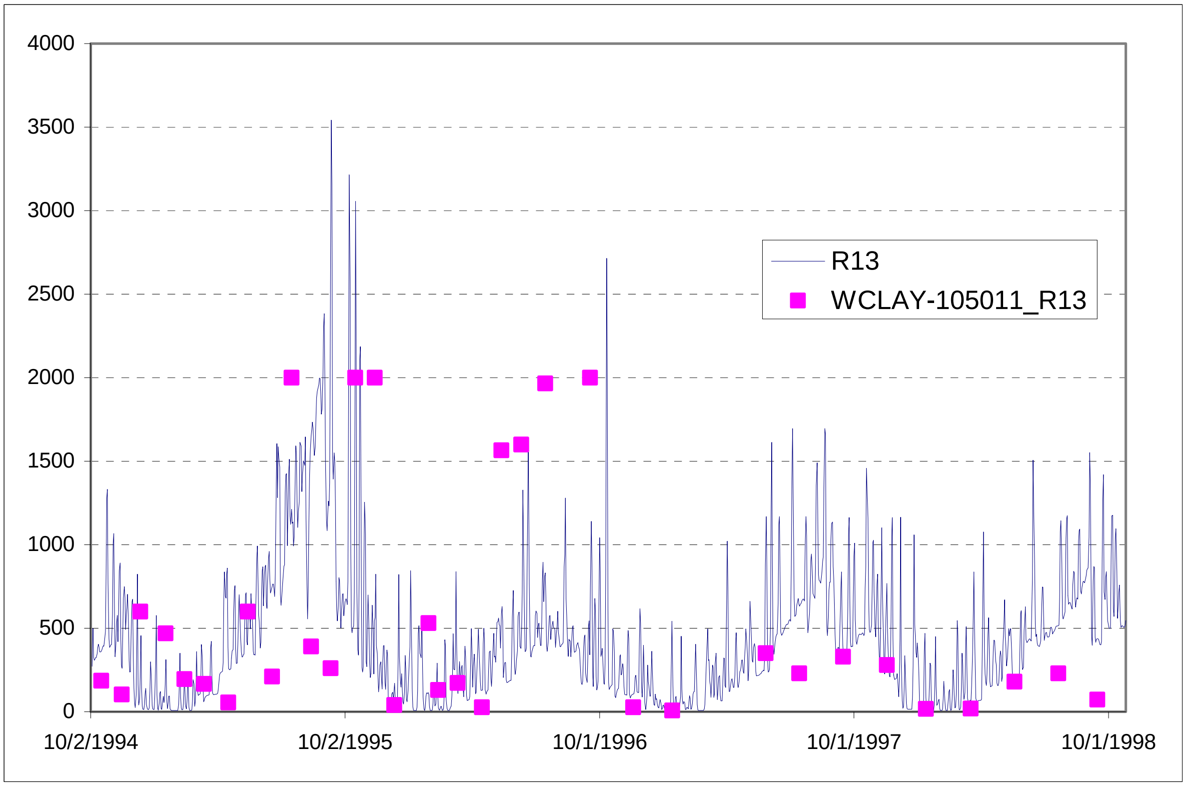
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998
R5
USGSWQN149_R5

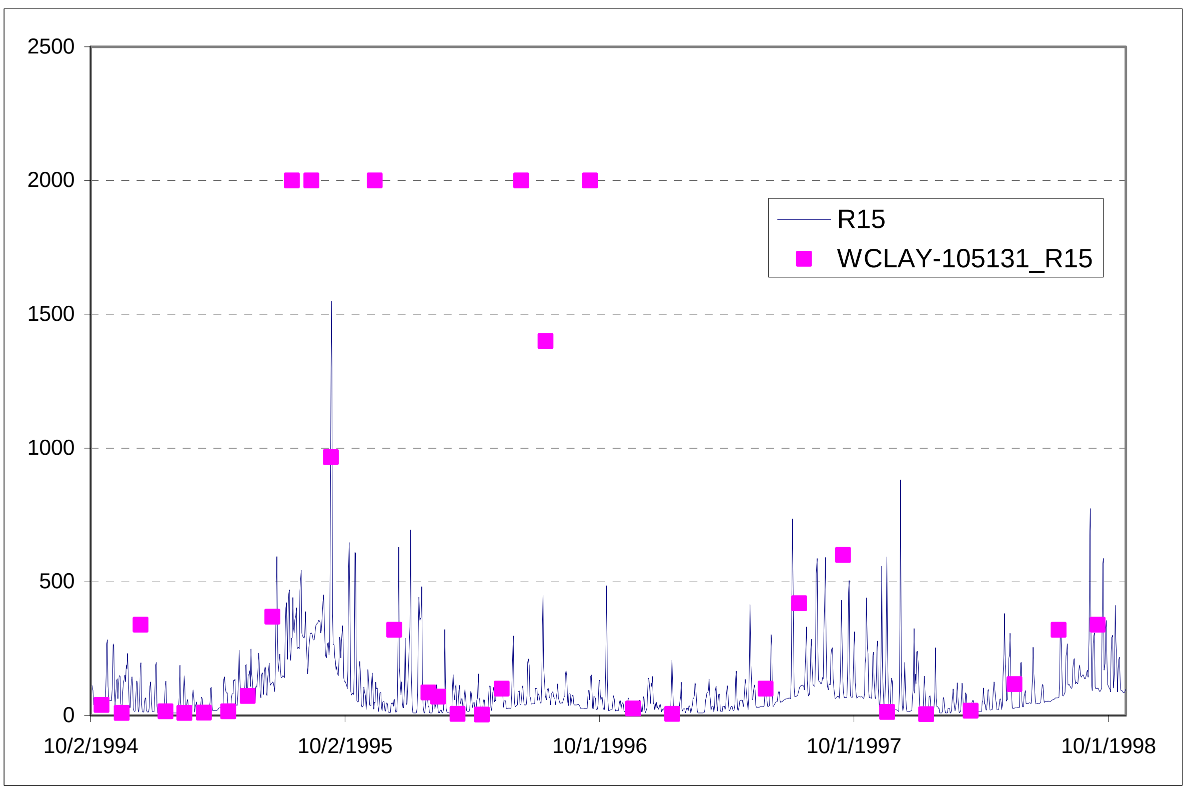


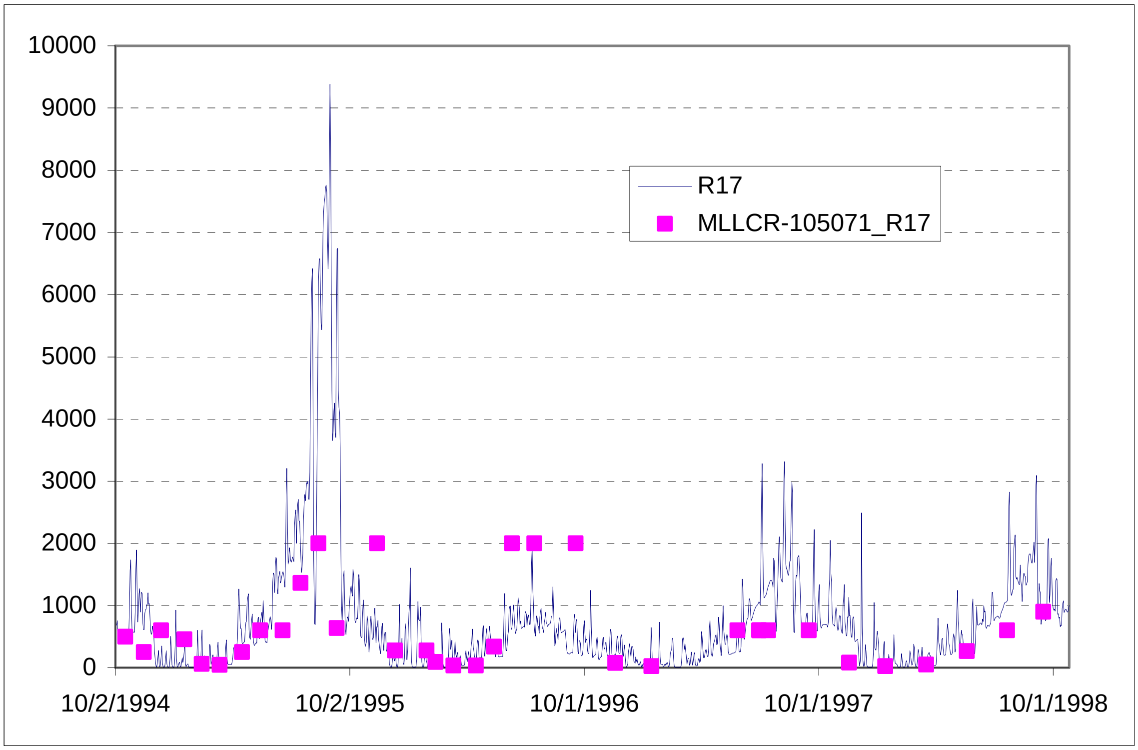
16000
14000
12000
10000
8000
6000
4000
2000
0
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998
R6
USGSWQN179_R6

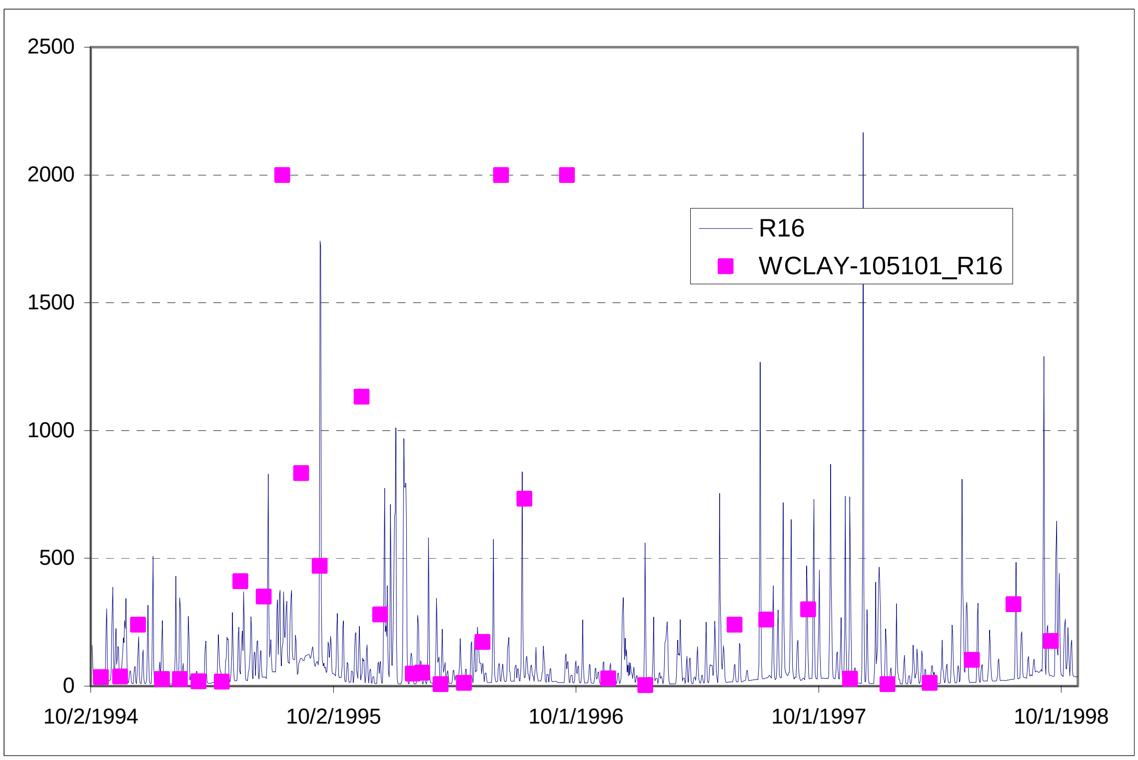

7000
6000
5000
4000
3000
2000
1000
0
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998
R10
CORE-105031_R10


4000
3500
3000
2500
2000
1500
1000
500
0
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998
R12
WCLAY-105151_R12


4000
3500
3000
2500
2000
1500
1000
500
0
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998
R13
WCLAY-105011_R13


2500
2000
1500
1000
500
0
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998
R15
WCLAY-105131_R15


10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998
R17
MLLCR-105071_R17


2500
2000
1500
1000
500
0
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998
R16
WCLAY-105101_R16

Appendix C

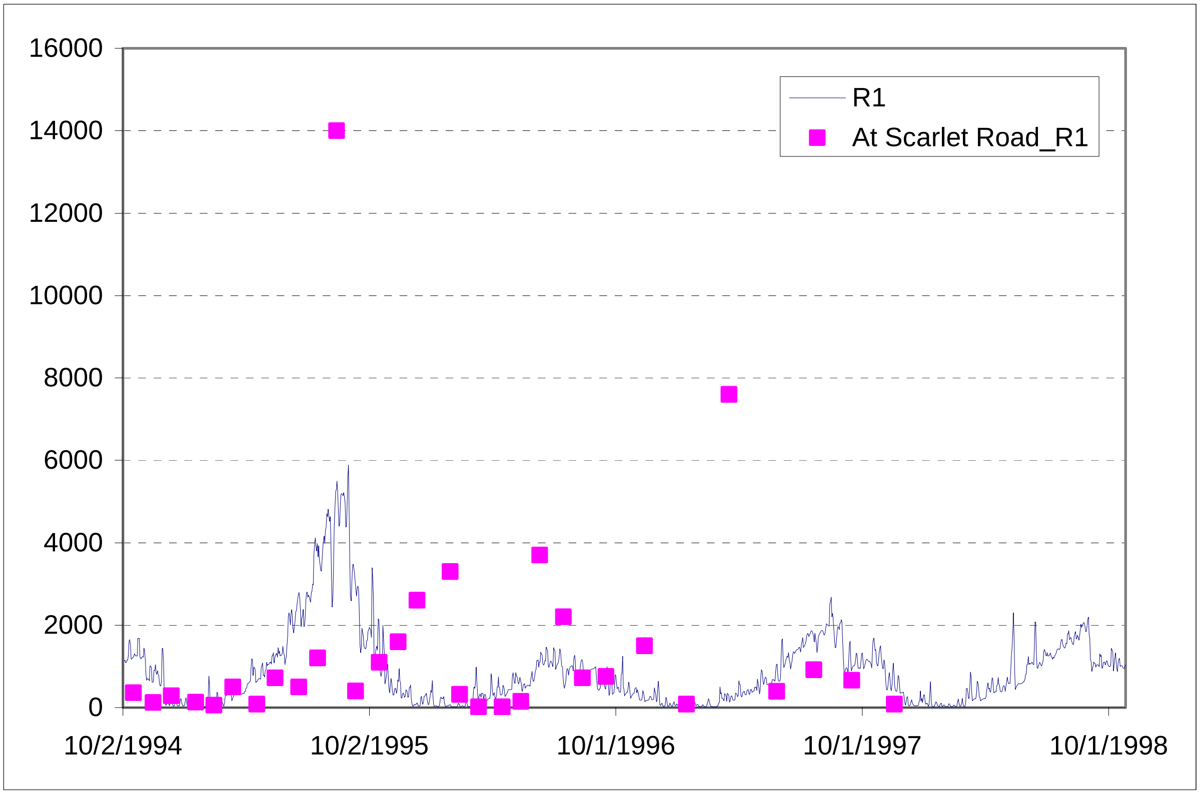
HSPF Model

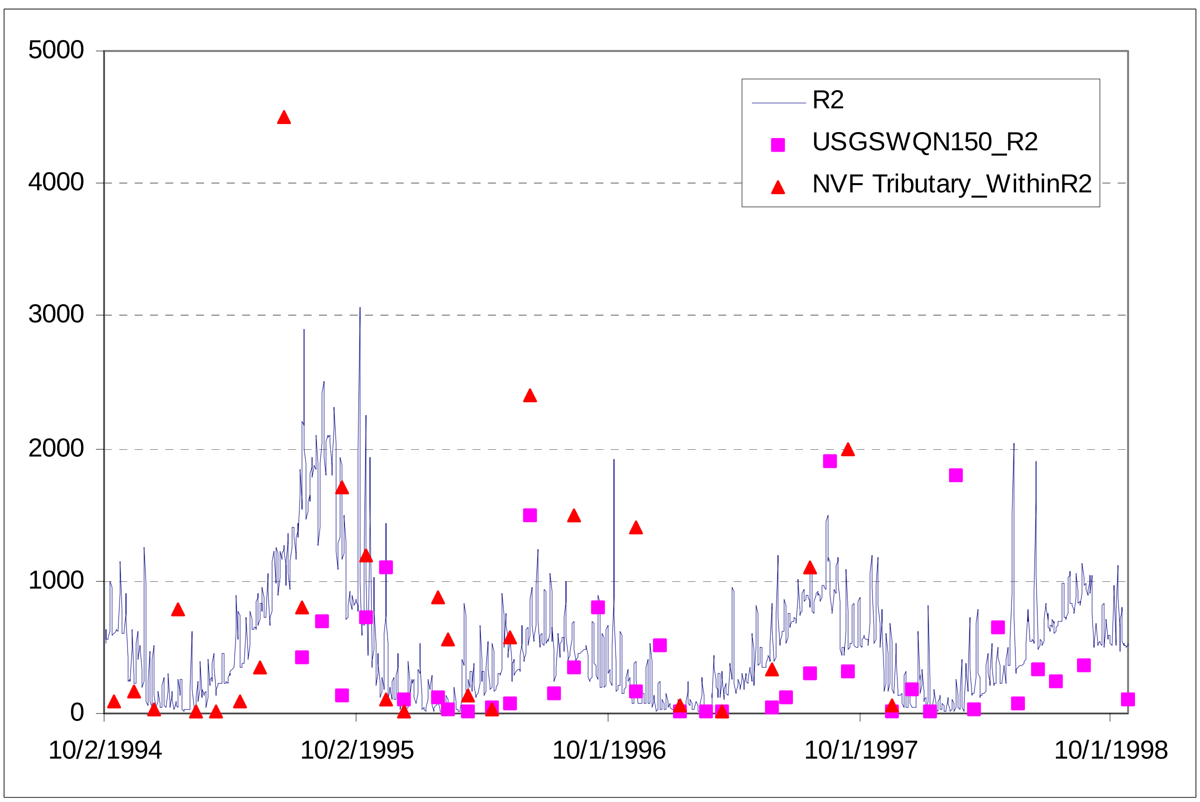
Enterococci Bacteria Simulation

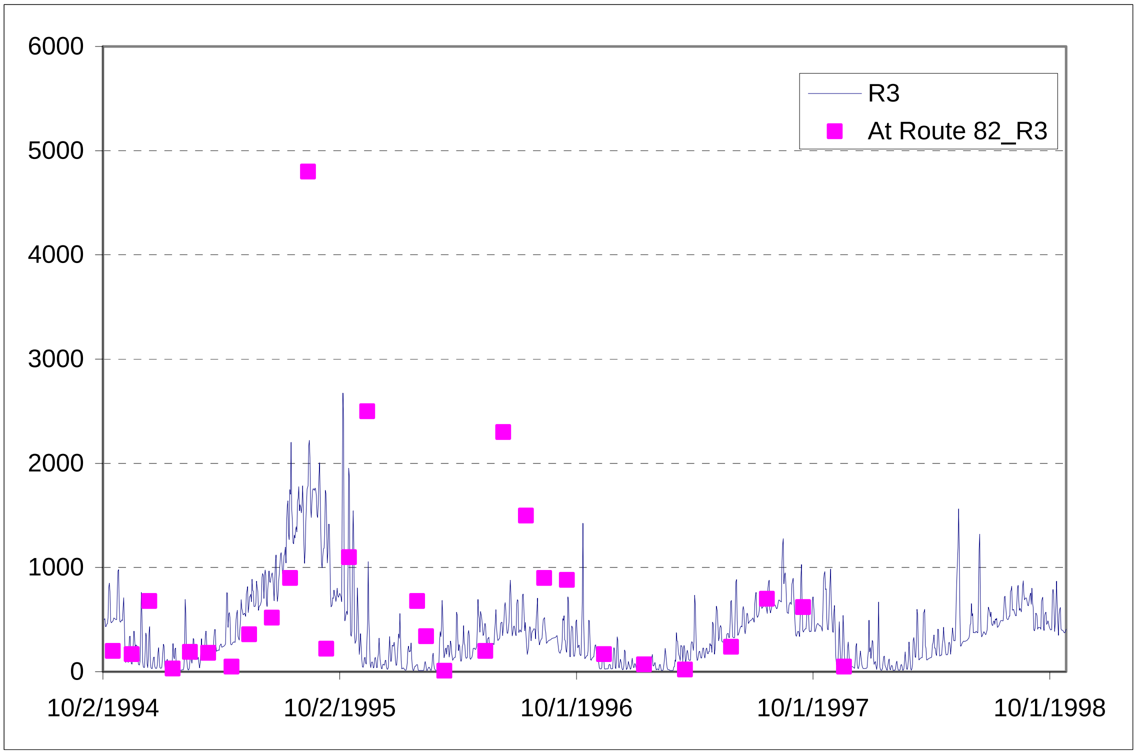
Time-series Calibration Results
(10/1/1994 to 10/29/1998)

Red Clay Creek Watershed

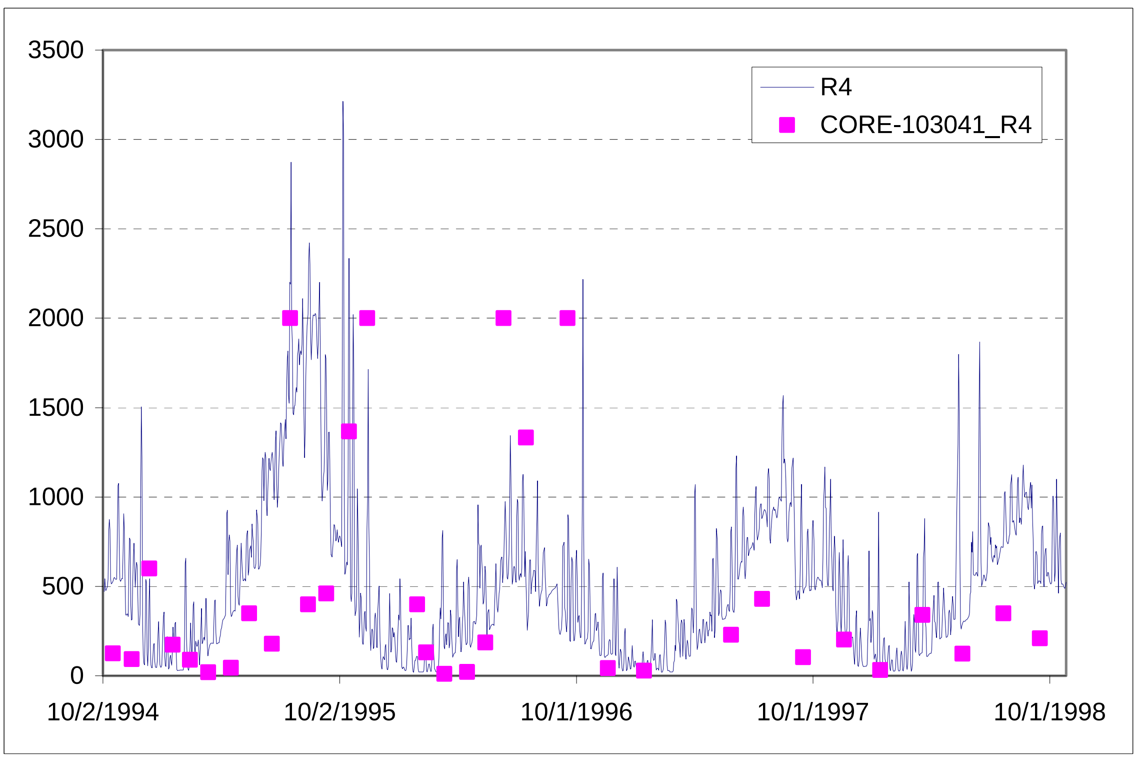
(y-axis units are cfu/100 mL)


16000
14000
12000
10000
8000
6000
4000
2000
0
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998
R1
At Scarlet Road_R1

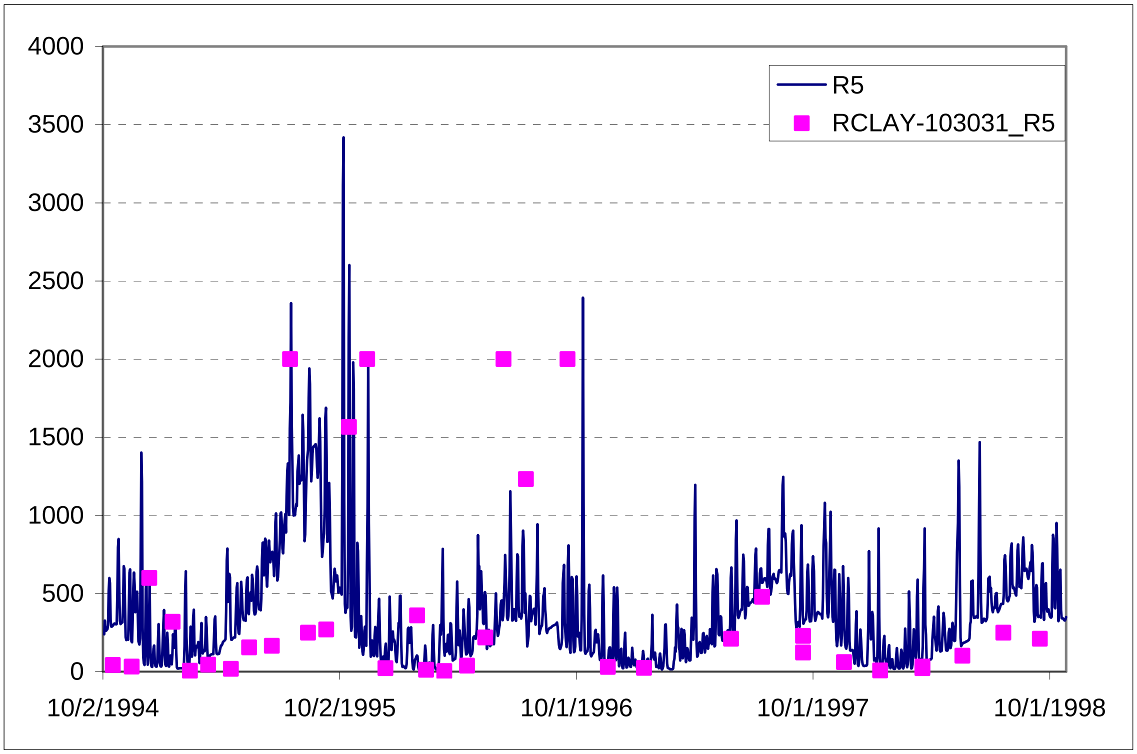

5000
4000
3000
2000
1000
0
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998
R2
USGSWQN150_R2
NVF Tributary_WithinR2

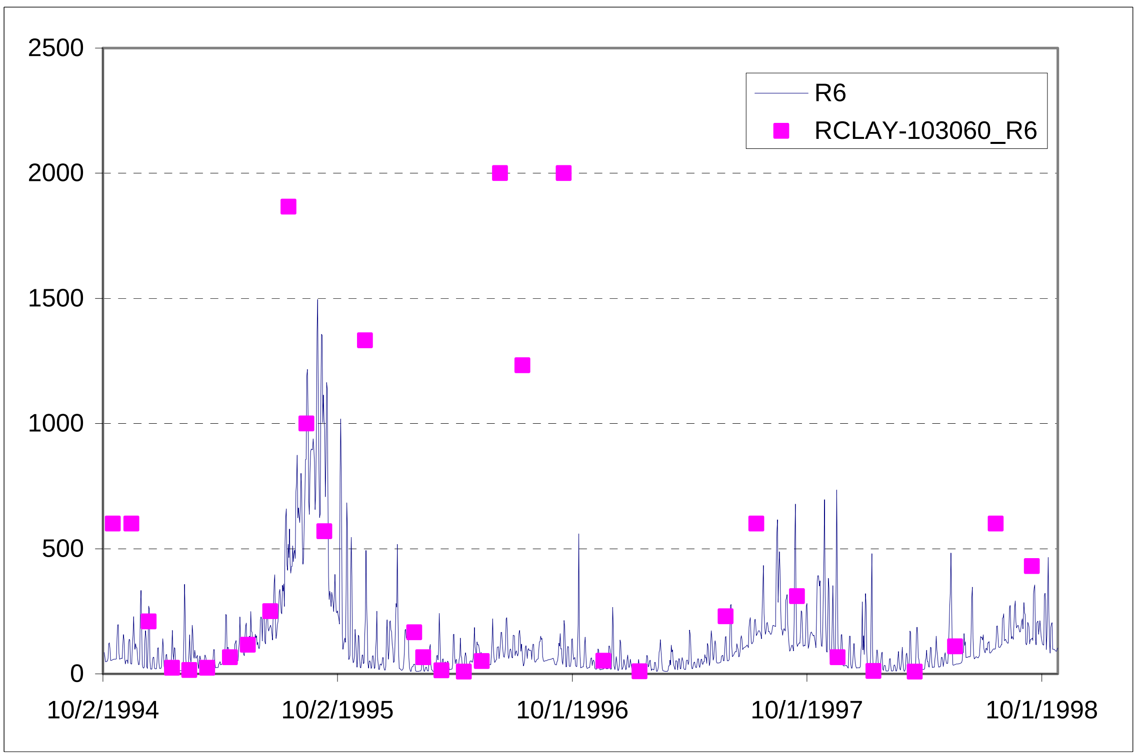


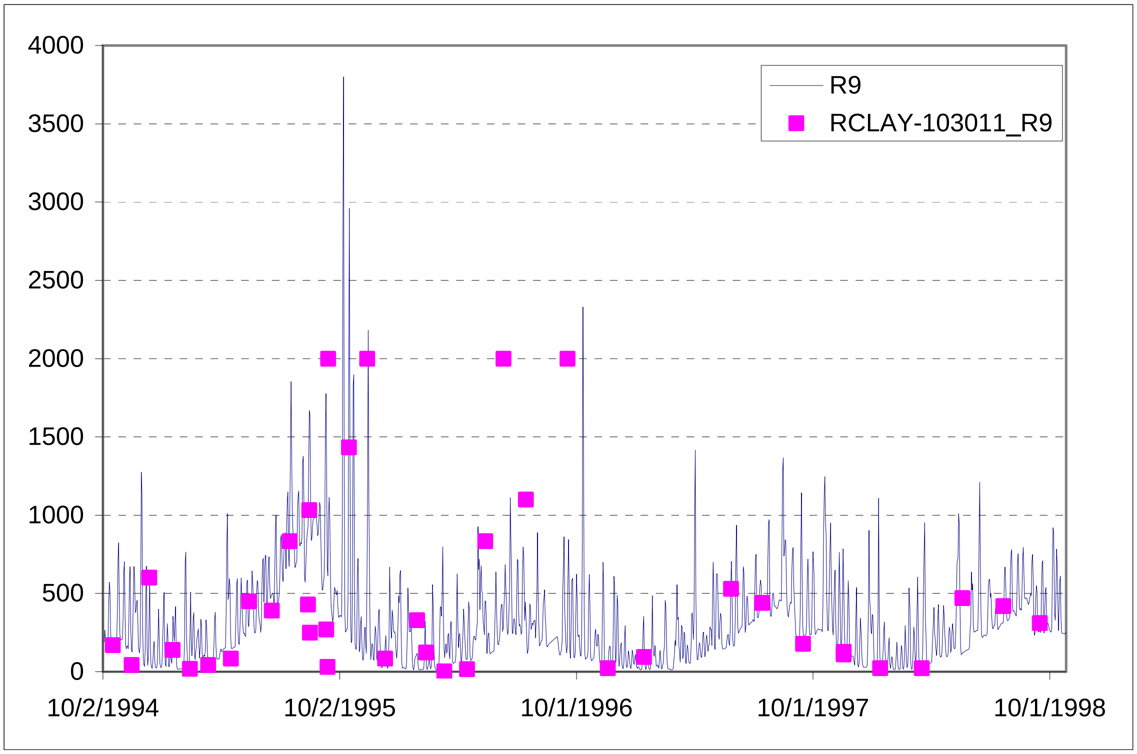
6000
5000
4000
3000
2000
1000
0
R3
At Route 82_R3
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998



3500
3000
2500
2000
1500
1000
500
0
R4
CORE-103041_R4
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998


4000
3500
3000
2500
2000
1500
1000
500
0
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998
R5
RCLAY-103031_R5


2500
2000
1500
1000
500
0
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998
R6
RCLAY-103060_R6



4000
3500
3000
2500
2000
1500
1000
500
0
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998
R9
RCLAY-103011_R9

Appendix D

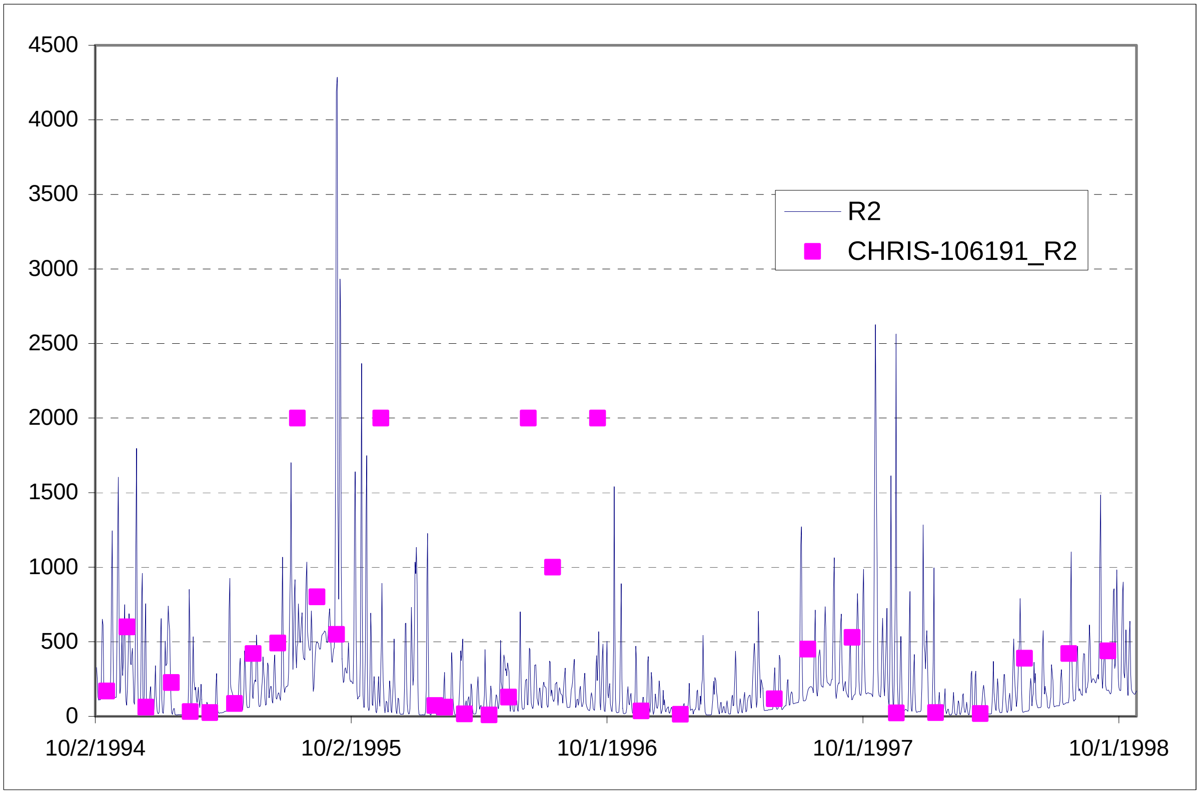
HSPF Model

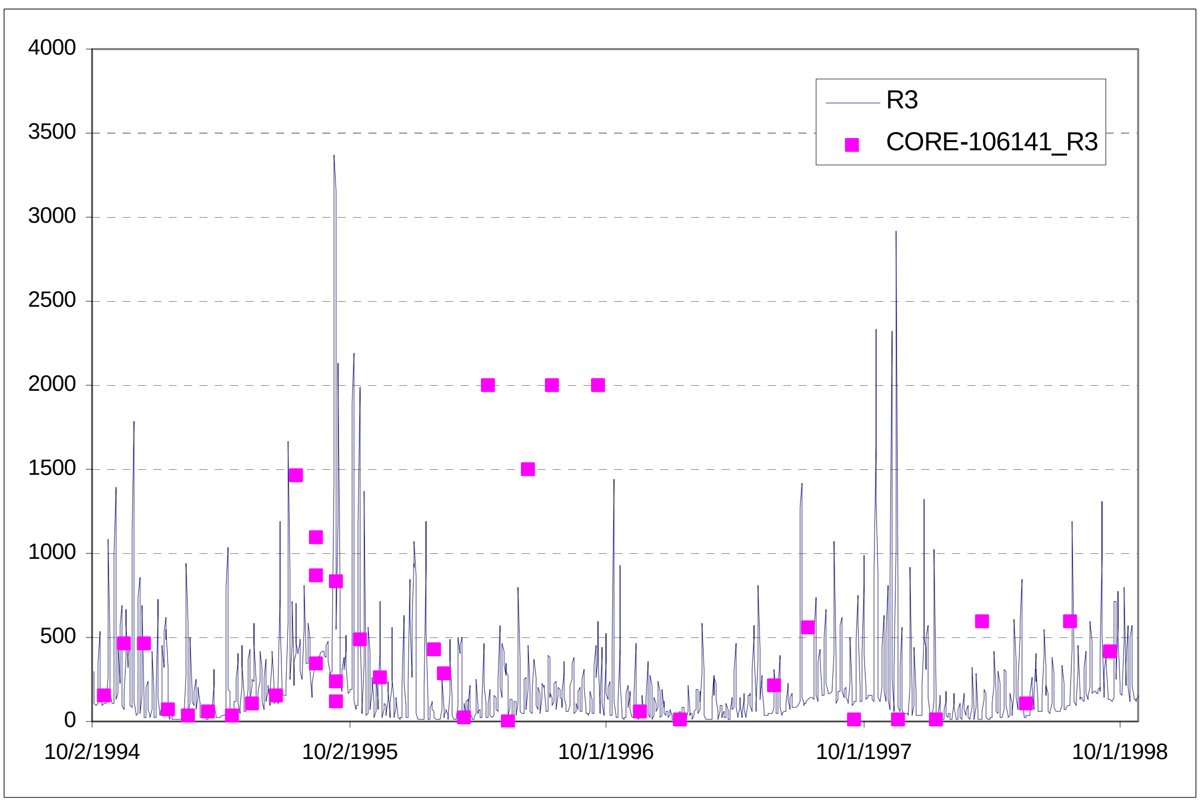
Enterococci Bacteria Simulation

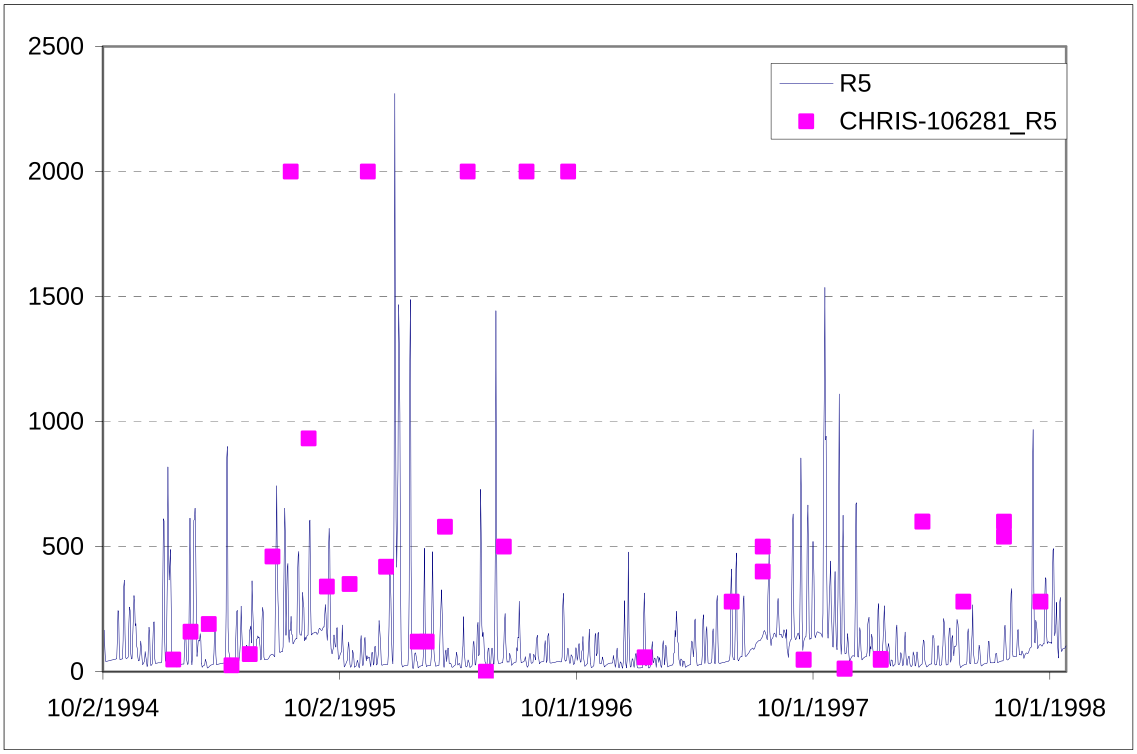
Time-series Calibration Results
(10/1/1994 to 10/29/1998)

Christina River Watershed

(y-axis units are cfu/100 mL)


4500
4000
3500
3000
2500
2000
1500
1000
500
0
R2
CHRIS-106191_R2
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998


4000
3500
3000
2500
2000
1500
1000
500
0
R3
CORE-106141_R3
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998



2500
2000
1500
1000
500
0
10/2/1994
10/2/1995
10/1/1996
10/1/1997
10/1/1998
R5
CHRIS-106281_R5

Appendix E

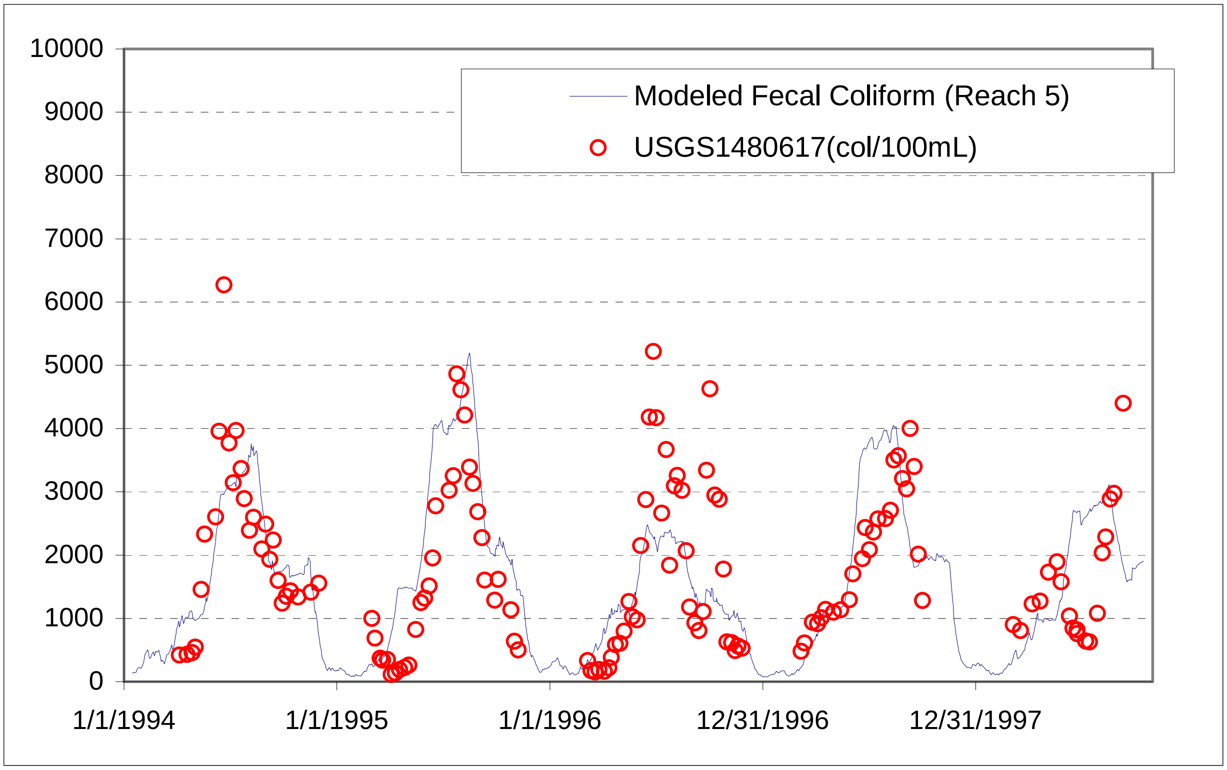
HSPF Model

Fecal Coliform Bacteria Simulation

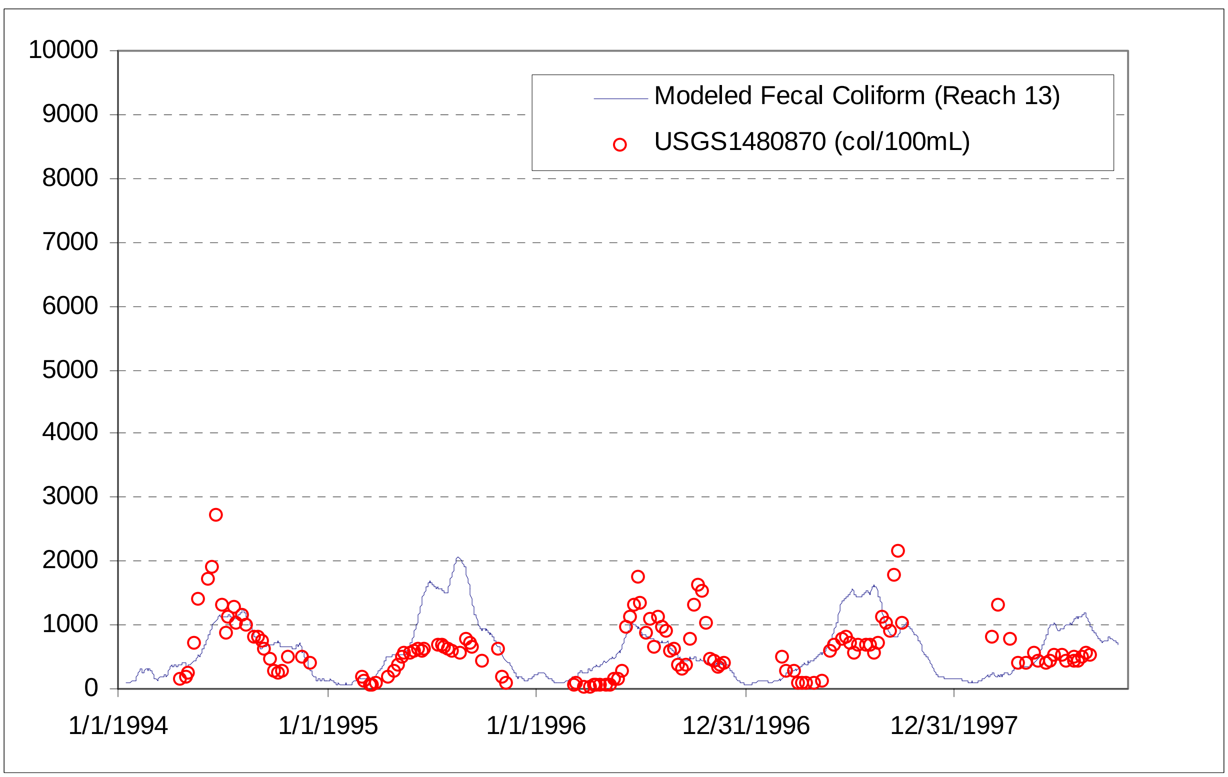
Time-series Calibration Results
(1/1/1994 to 10/29/1998)

Brandywine Creek Watershed
at
Modena (01480617)
Downingtown (01480870)
Chadds Ford (01481000)

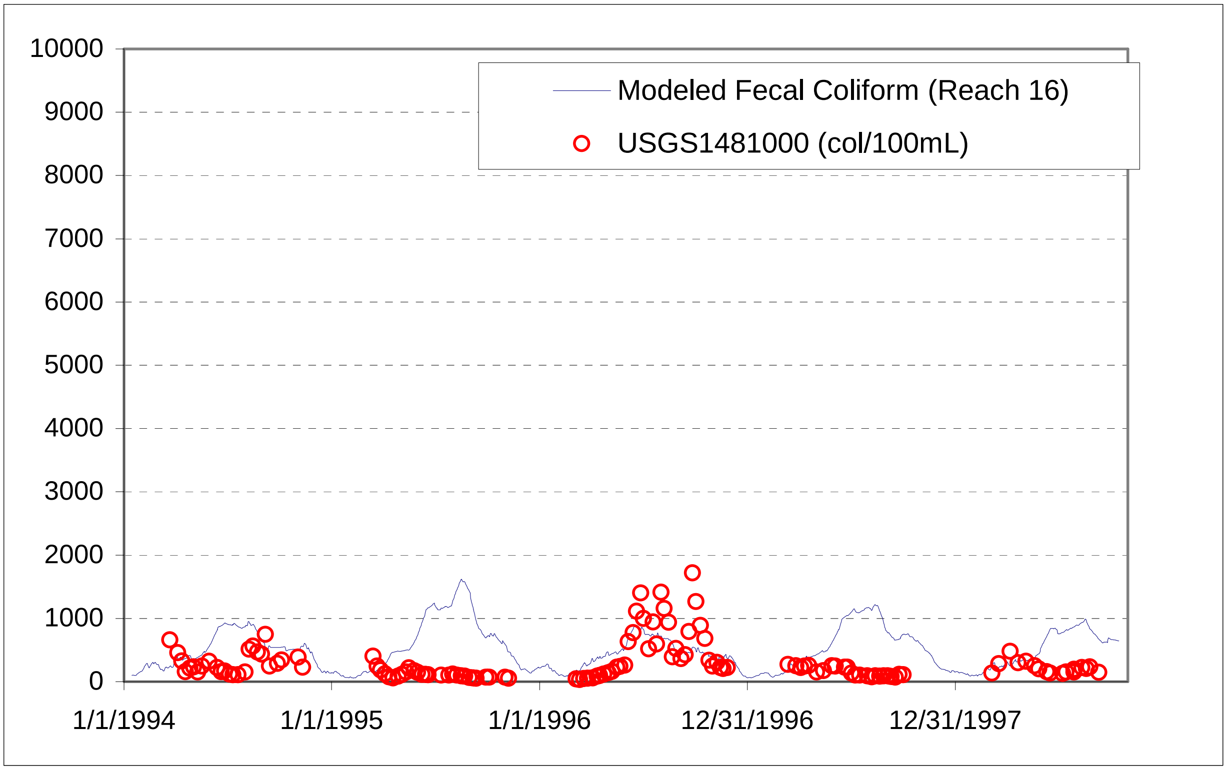
(y-axis units: cfu/100mL)



10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
Modeled Fecal Coliform (Reach 5)
USGS1480617(col/100mL)



10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
Modeled Fecal Coliform (Reach 13)
USGS1480870 (col/100mL)



10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
Modeled Fecal Coliform (Reach 16)
USGS1481000 (col/100mL)

Appendix F

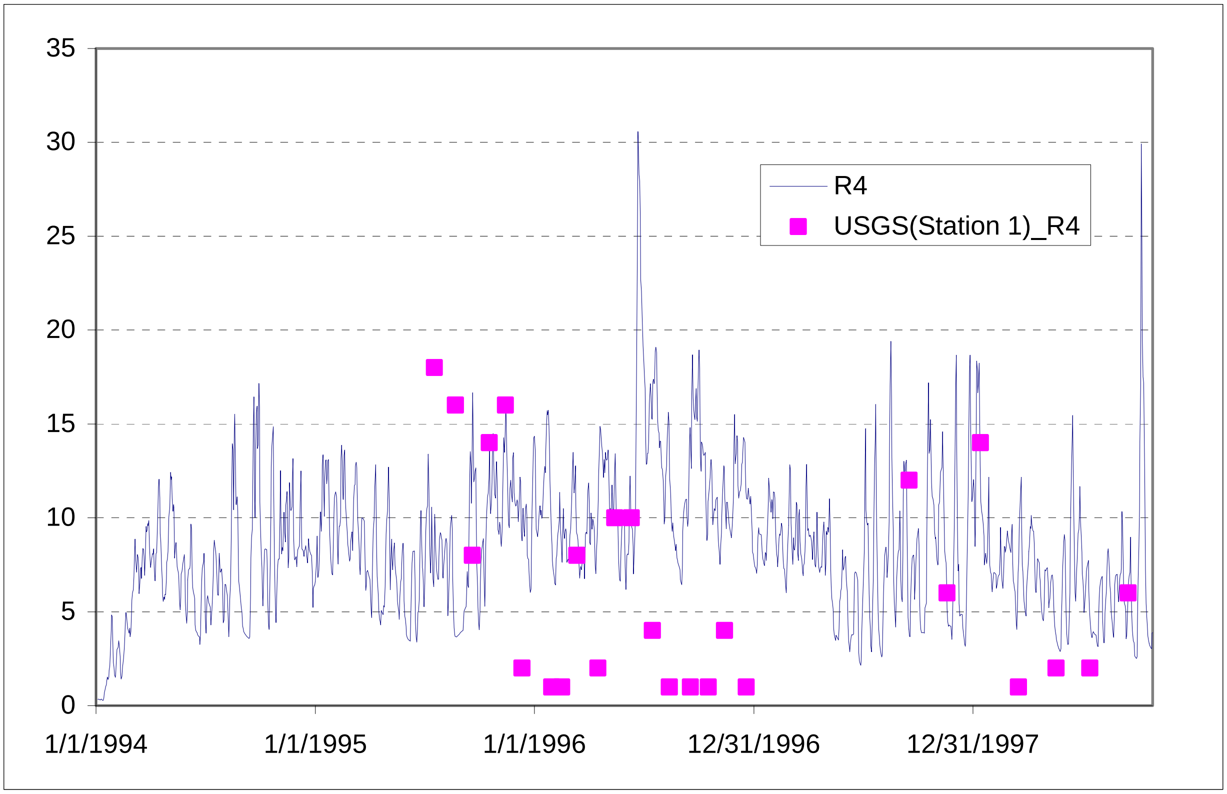
HSPF Model

Suspended Sediment Simulation

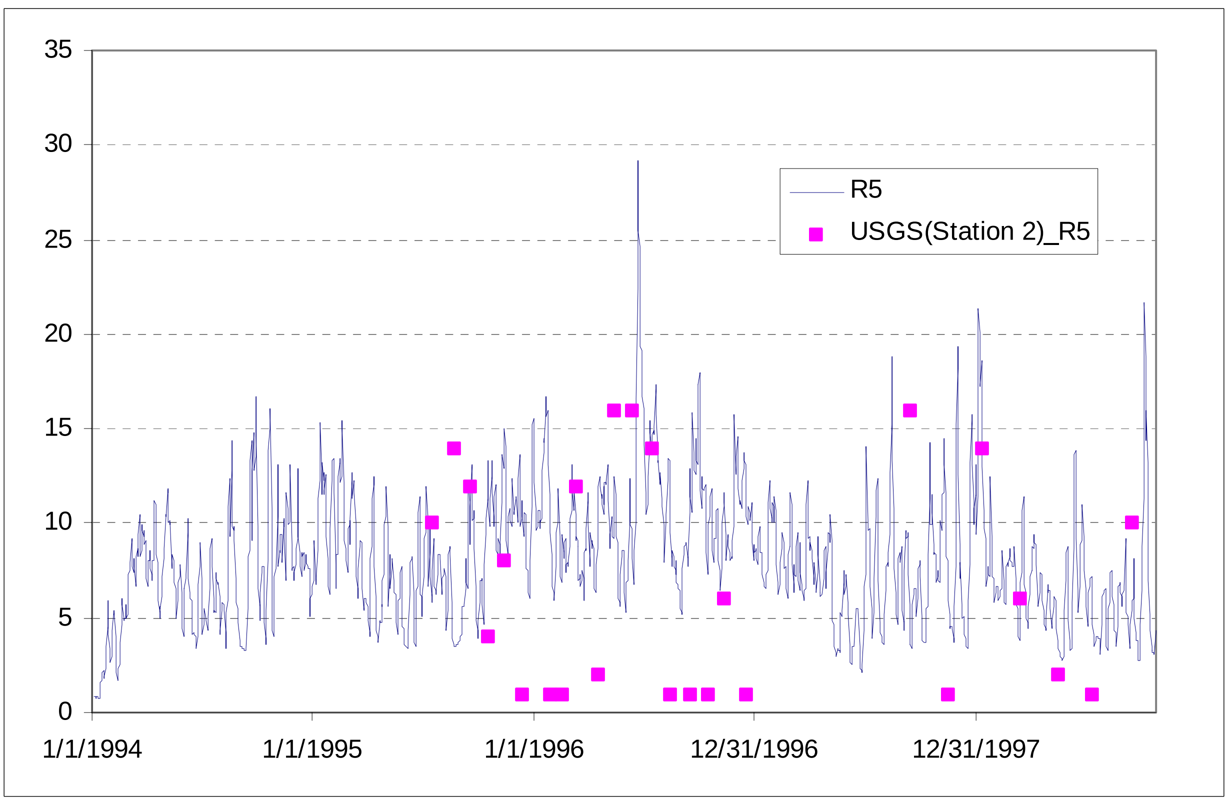
Time-series Calibration Results
(1/1/1994 to 10/29/1998)

Brandywine Creek Watershed

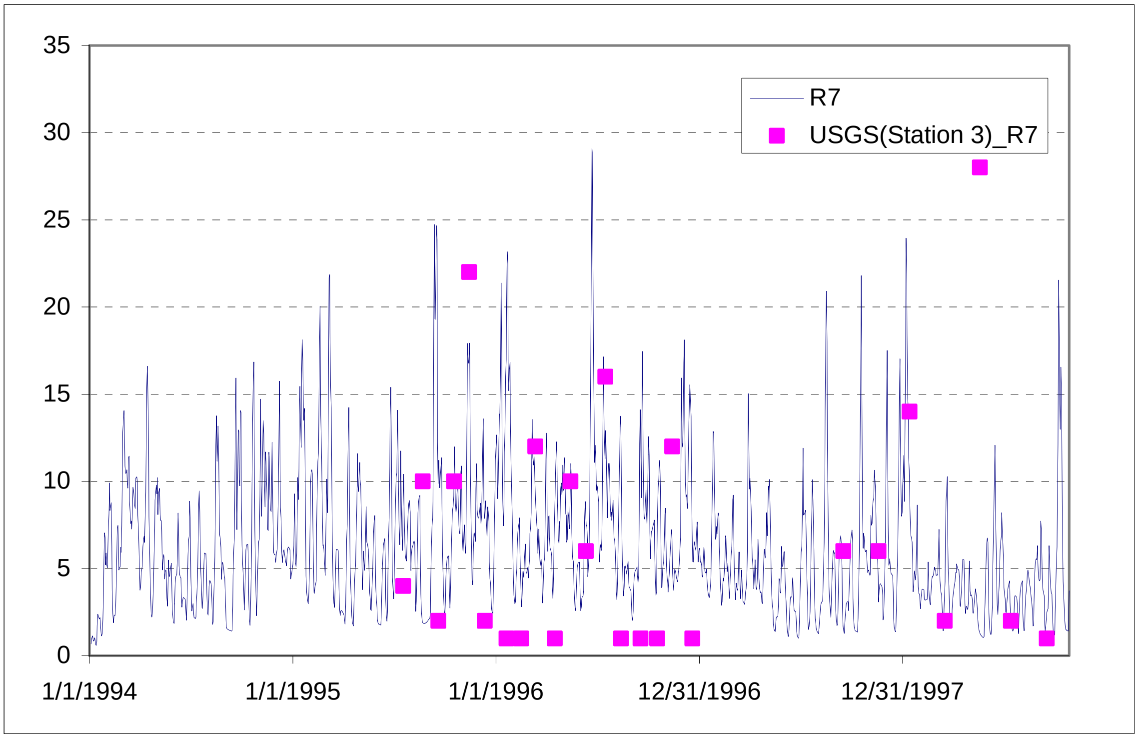
(y-axis units are mg/L)

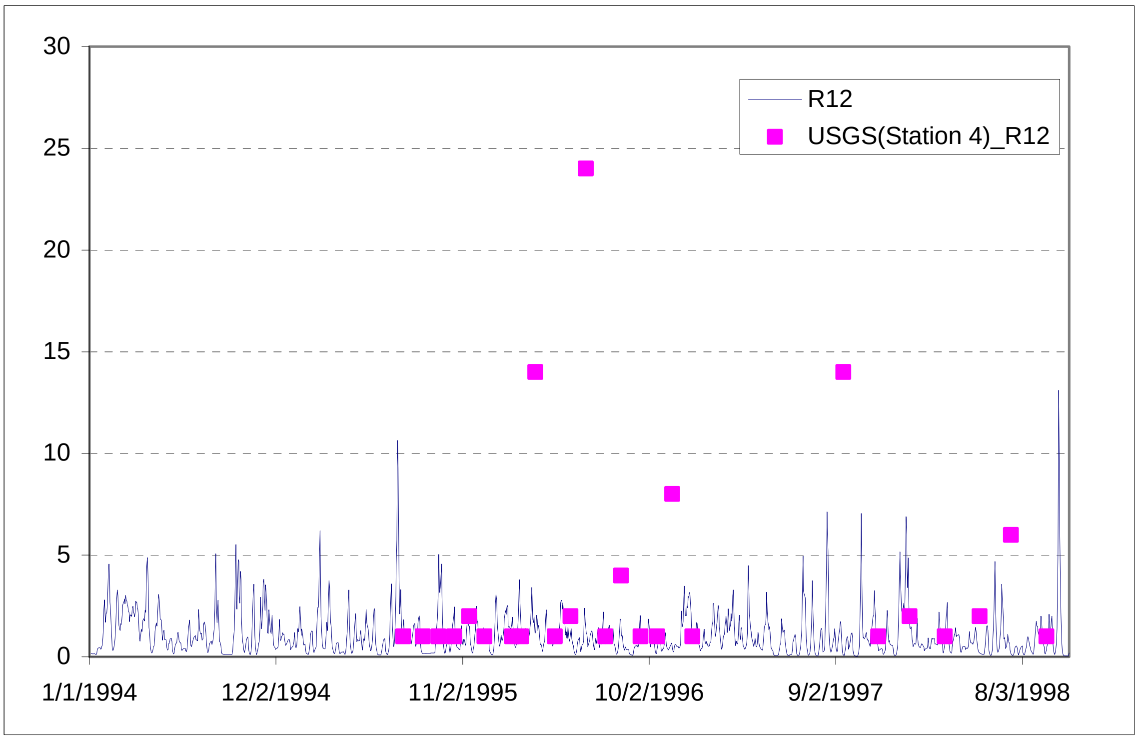


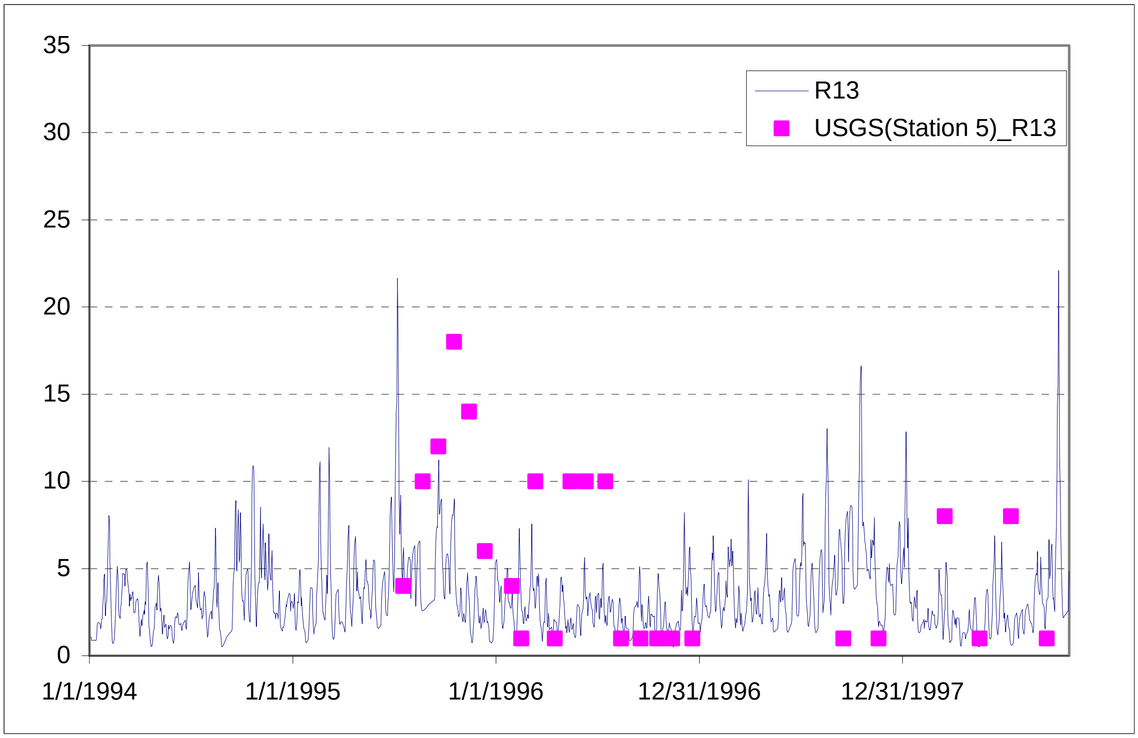
35
30
25
20
15
10
5
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
R4
USGS(Station 1)_R4

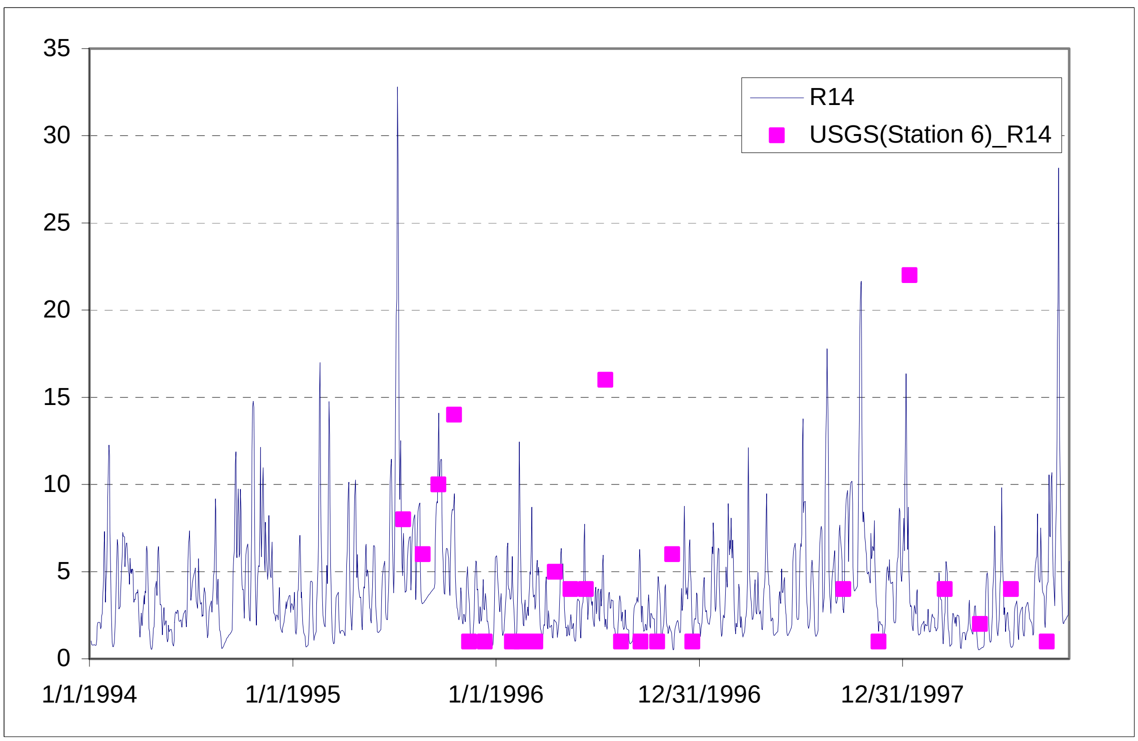


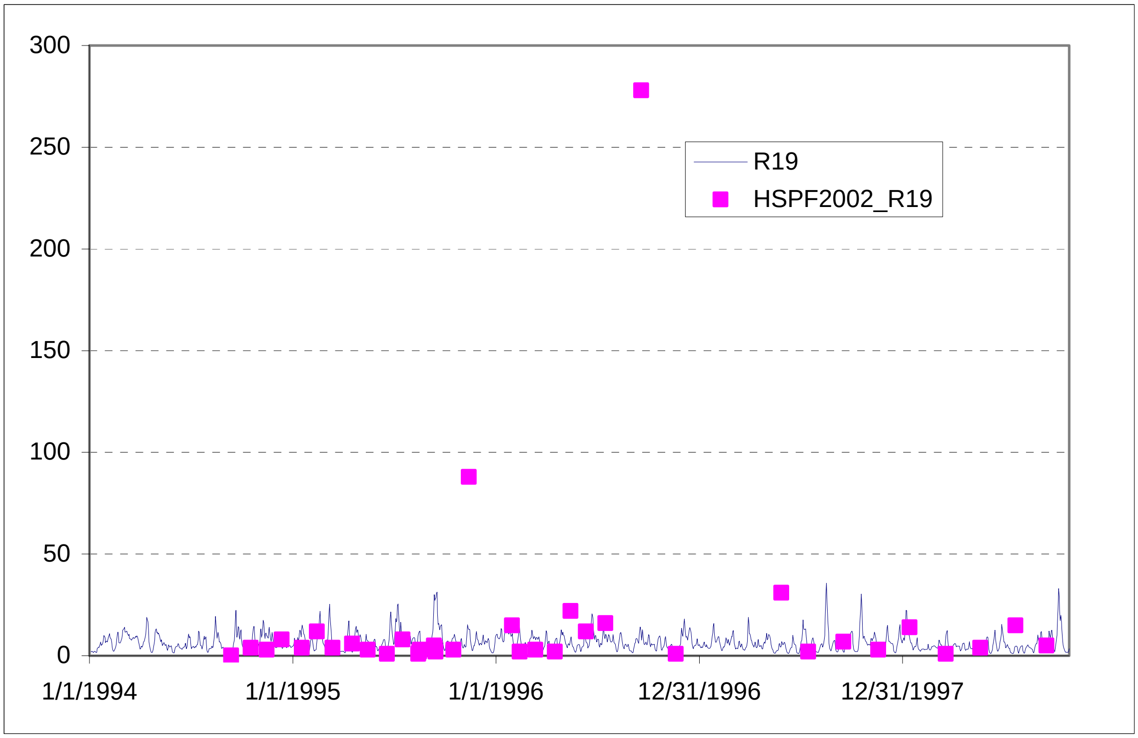
35
30
25
20
15
10
5
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
R5
USGS(Station 2)_R5


35
30
25
20
15
10
5
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
R7
USGS(Station 3)_R7


30
25
20
15
10
5
0
1/1/1994
12/2/1994
11/2/1995
10/2/1996
9/2/1997
8/3/1998
R12
USGS(Station 4)_R12


35
30
25
20
15
10
5
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
R13
USGS(Station 5)_R13


35
30
25
20
15
10
5
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
R14
USGS(Station 6)_R14



300
250
200
150
100
50
0
1/1/1994
1/1/1995
1/1/1996
12/31/1996
12/31/1997
R19
HSPF2002_R19

Appendix G

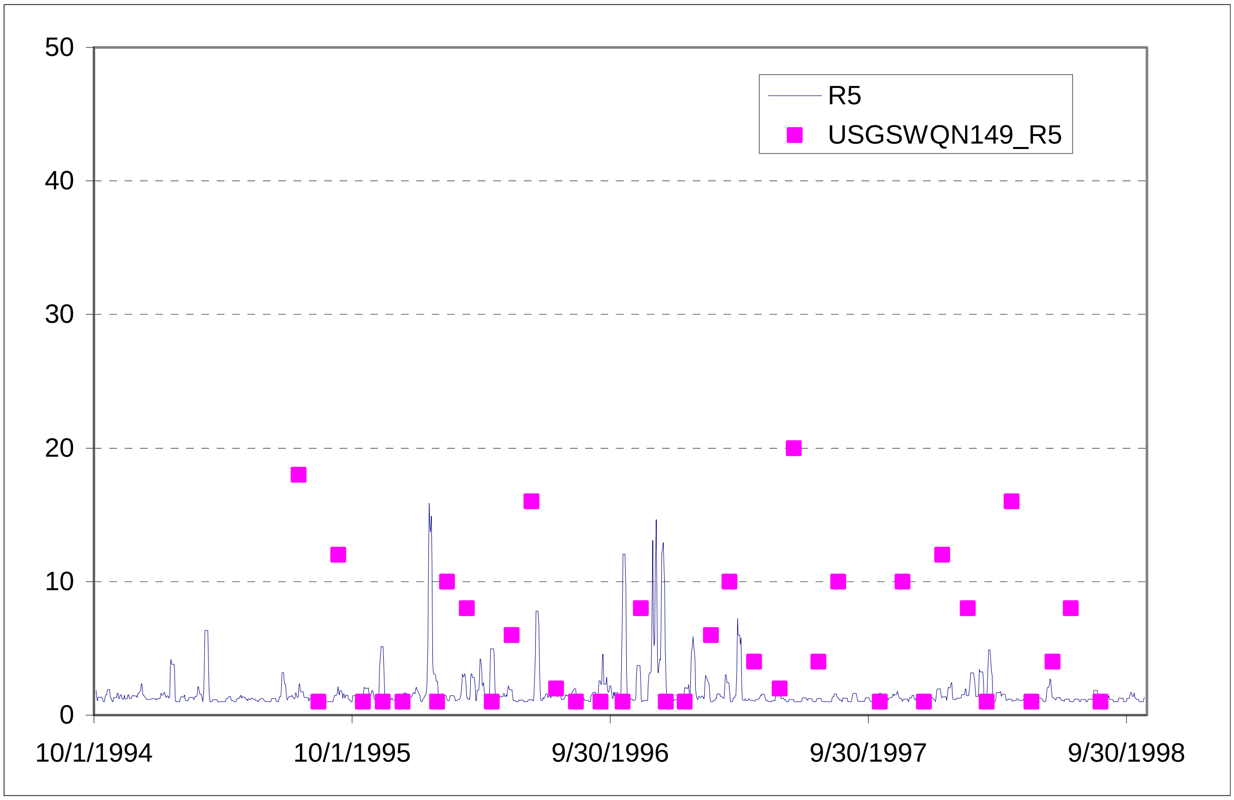
HSPF Model

Suspended Sediment Simulation

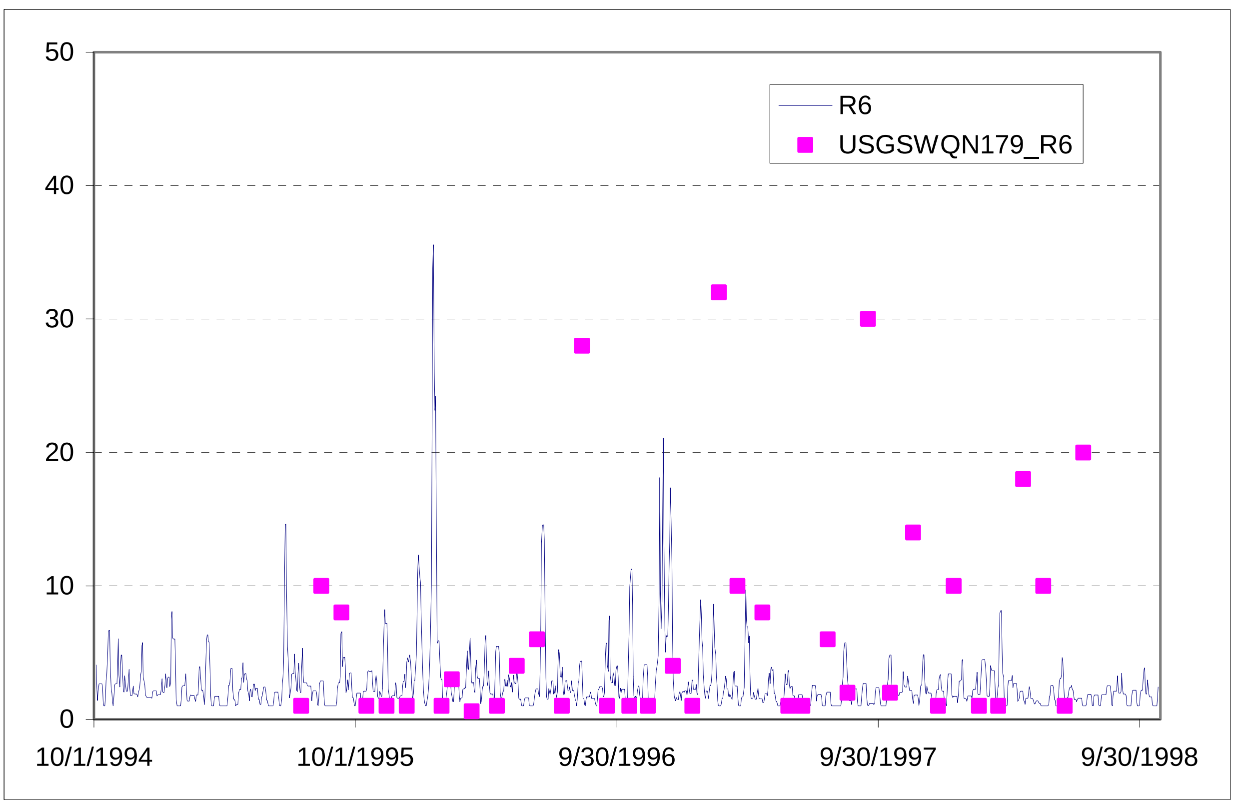
Time-series Calibration Results
(10/1/1994 to 10/29/1998)

White Clay Creek Watershed

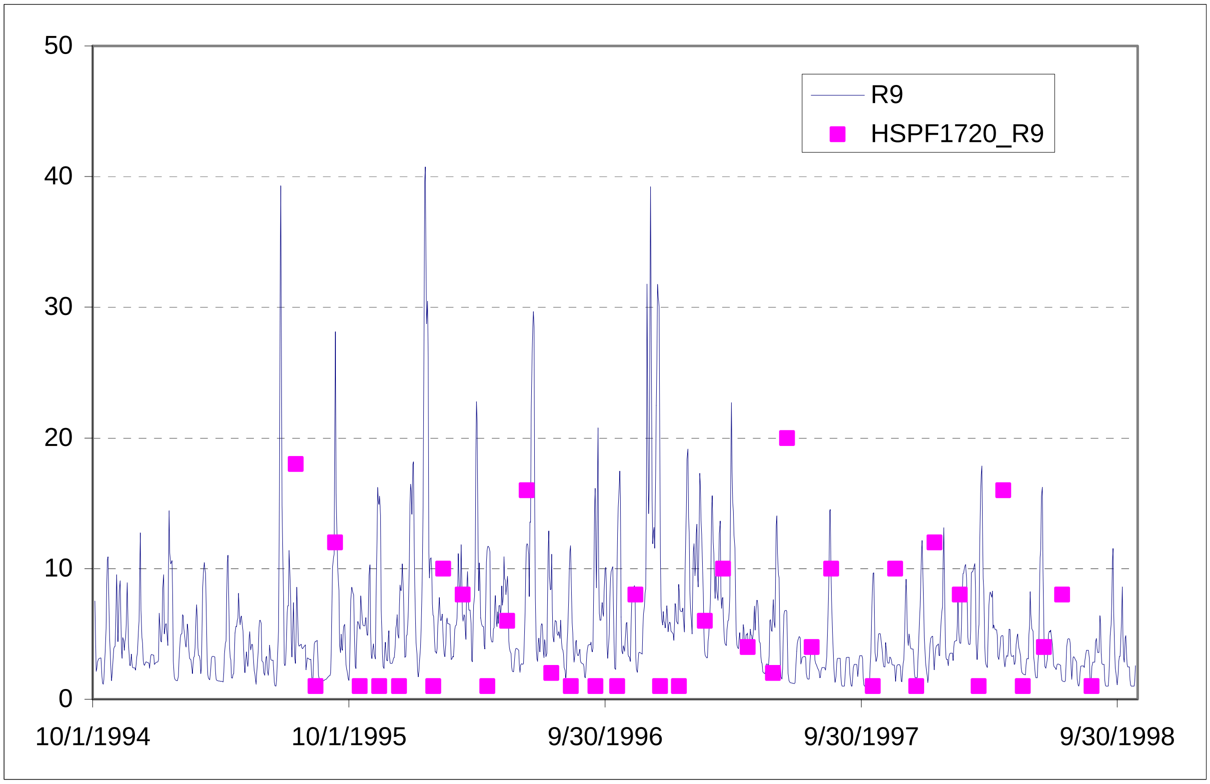
(y-axis units are mg/L)

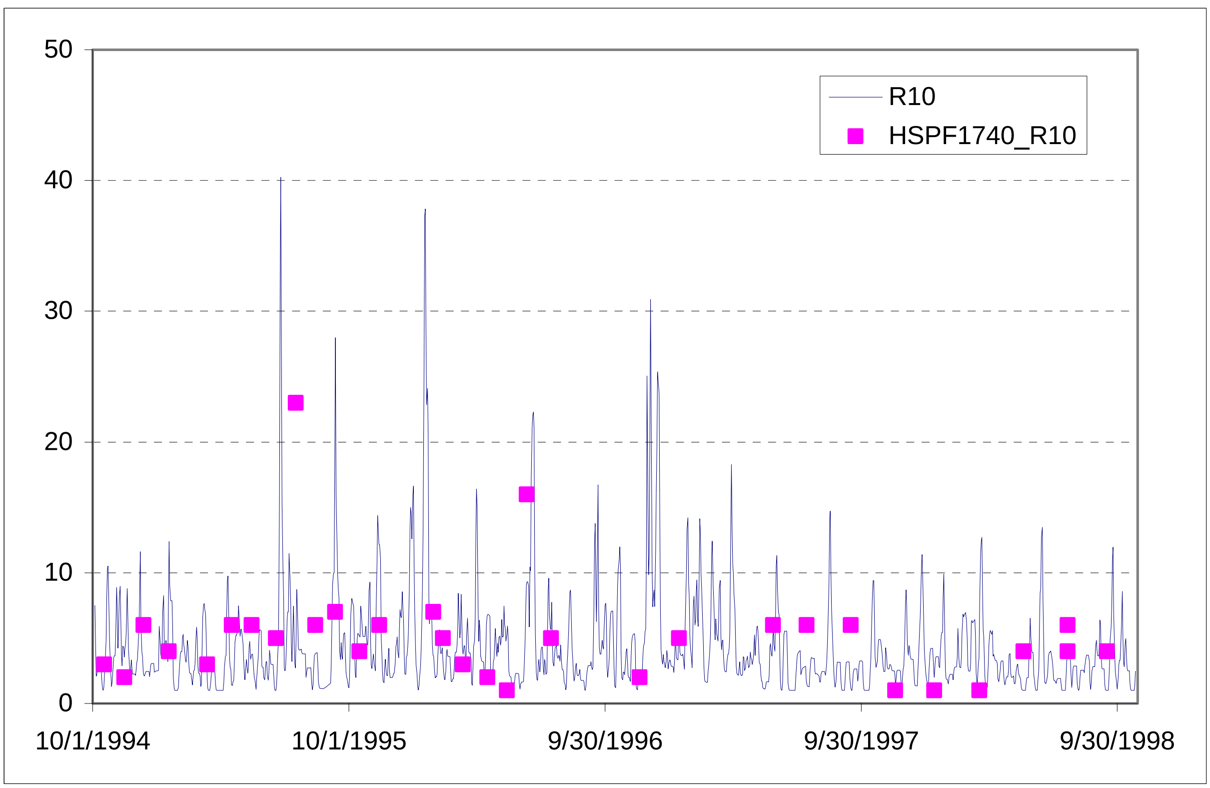


50
40
30
20
10
0
R5
USGSWQN149_R5
10/1/1994
10/1/1995
9/30/1996
9/30/1997
9/30/1998



50
40
30
20
10
0
R6
USGSWQN179_R6
10/1/1994
10/1/1995
9/30/1996
9/30/1997
9/30/1998


50
40
30
20
10
0
10/1/1994
10/1/1995
9/30/1996
9/30/1997
9/30/1998
R9
HSPF1720_R9


50
40
30
20
10
0
10/1/1994
10/1/1995
9/30/1996
9/30/1997
9/30/1998
R10
HSPF1740_R10

Appendix H

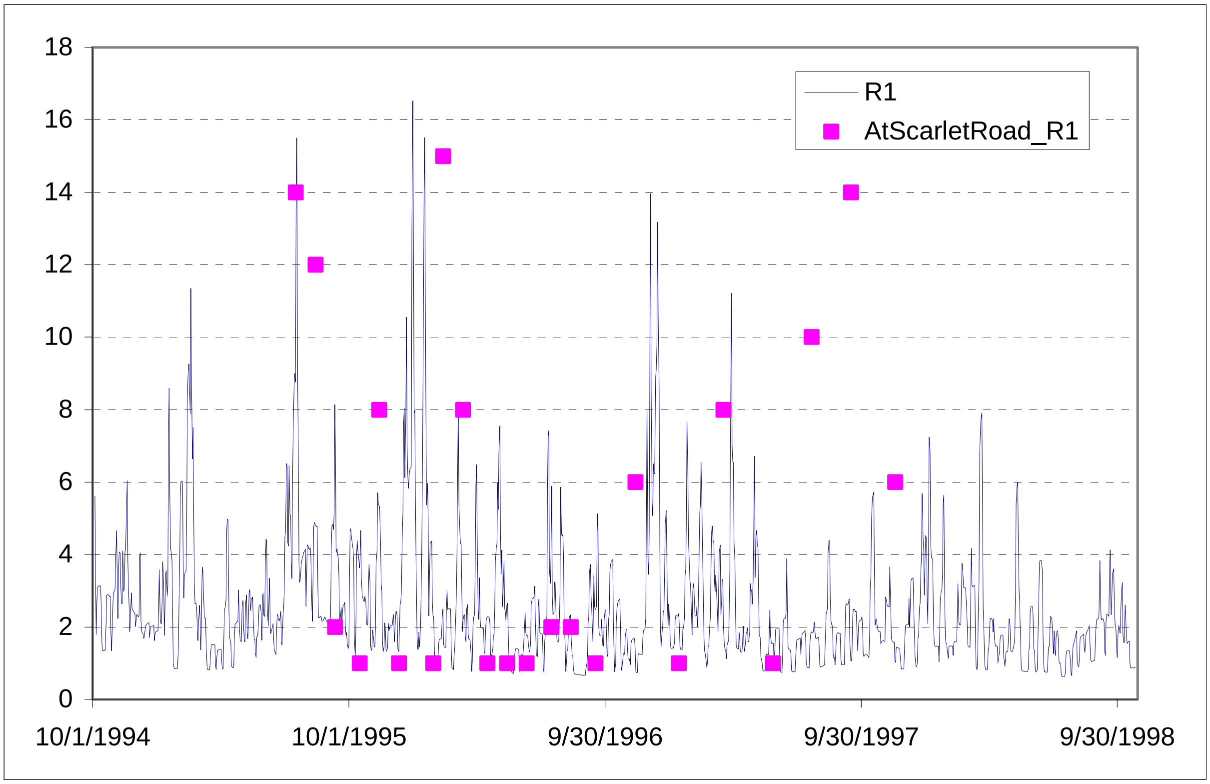
HSPF Model

Suspended Sediment Simulation

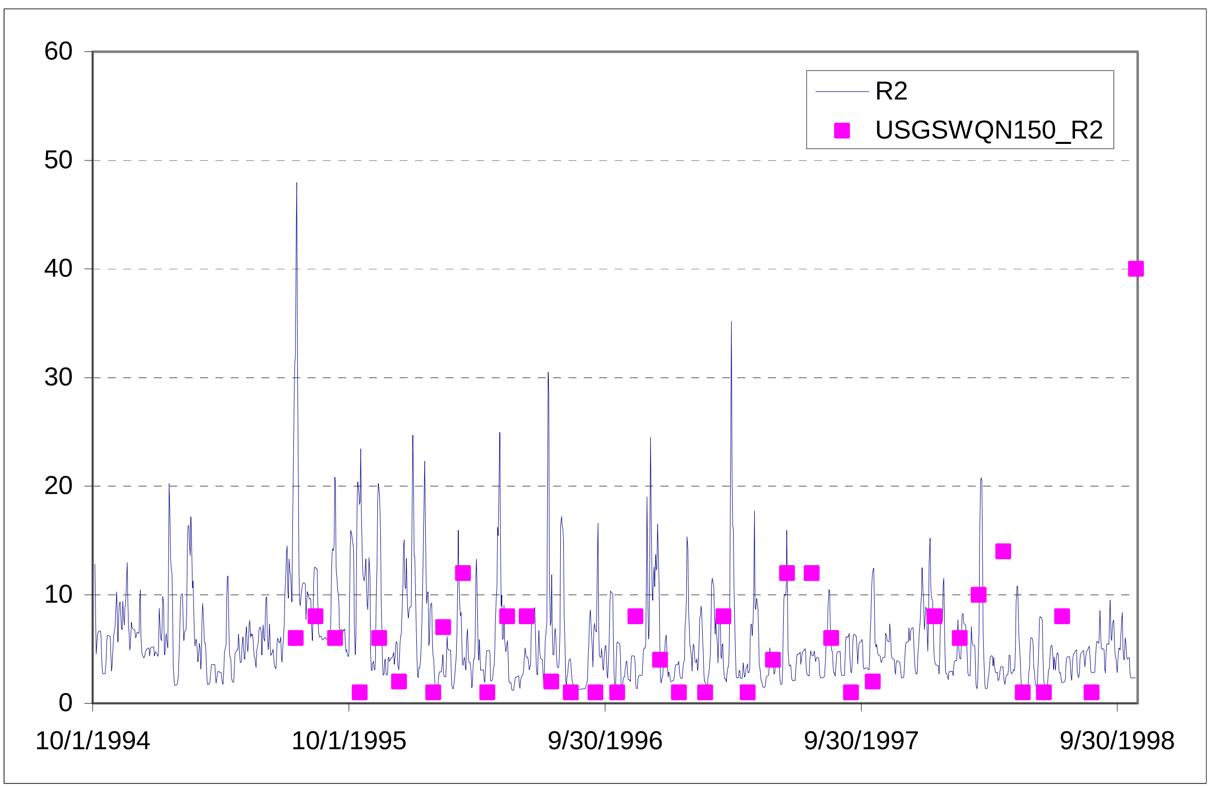
Time-series Calibration Results
(10/1/1994 to 10/29/1998)

Red Clay Creek Watershed

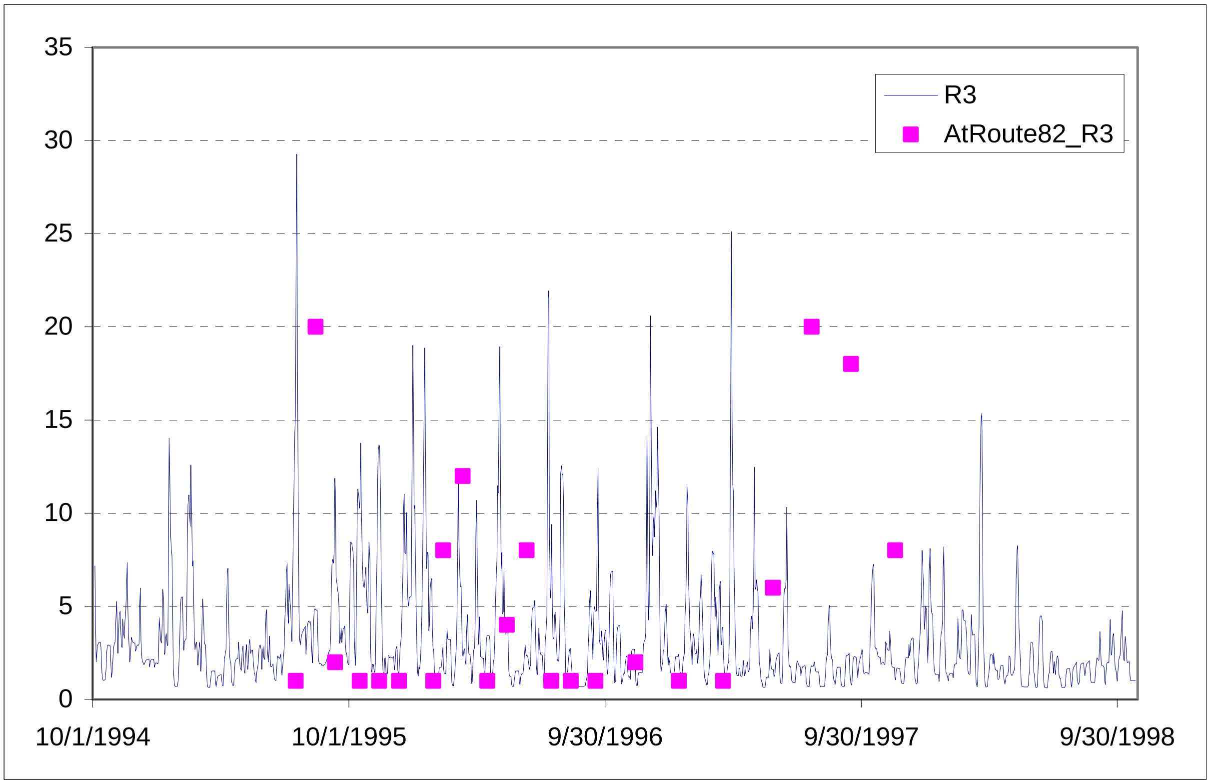
(y-axis units are mg/L)

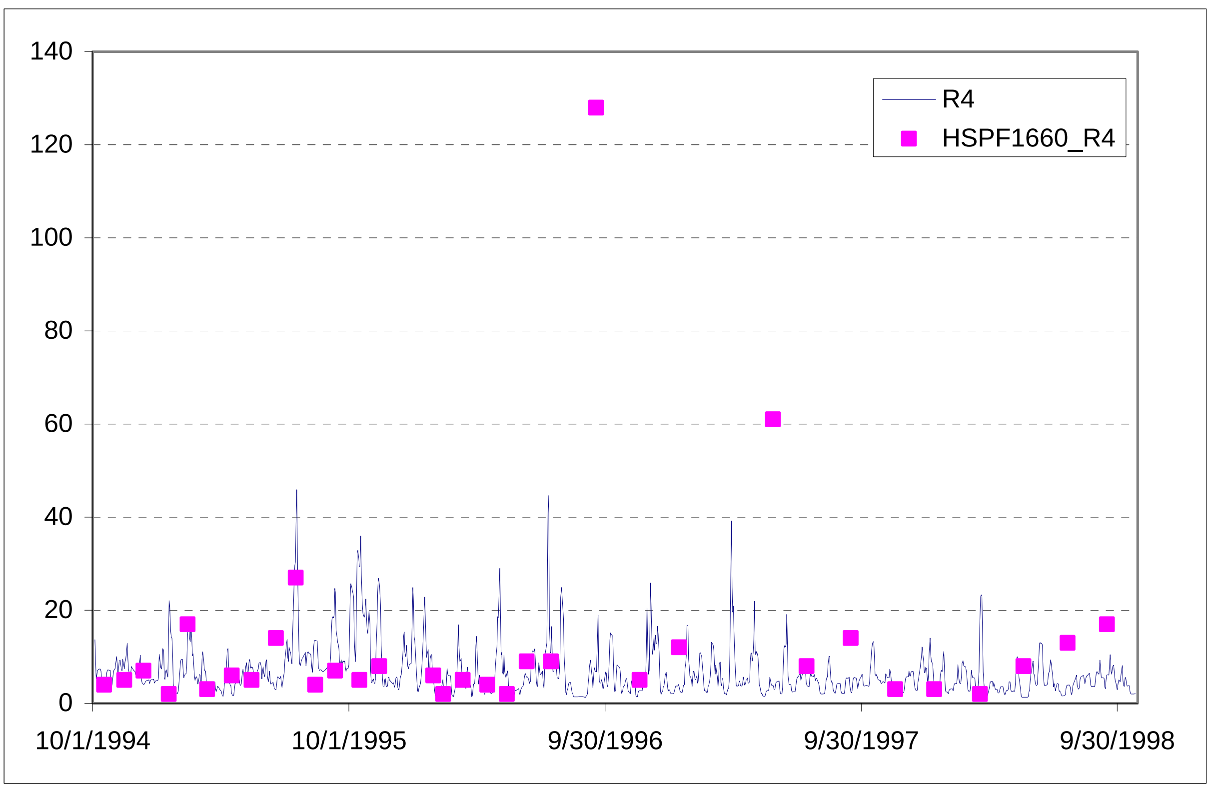


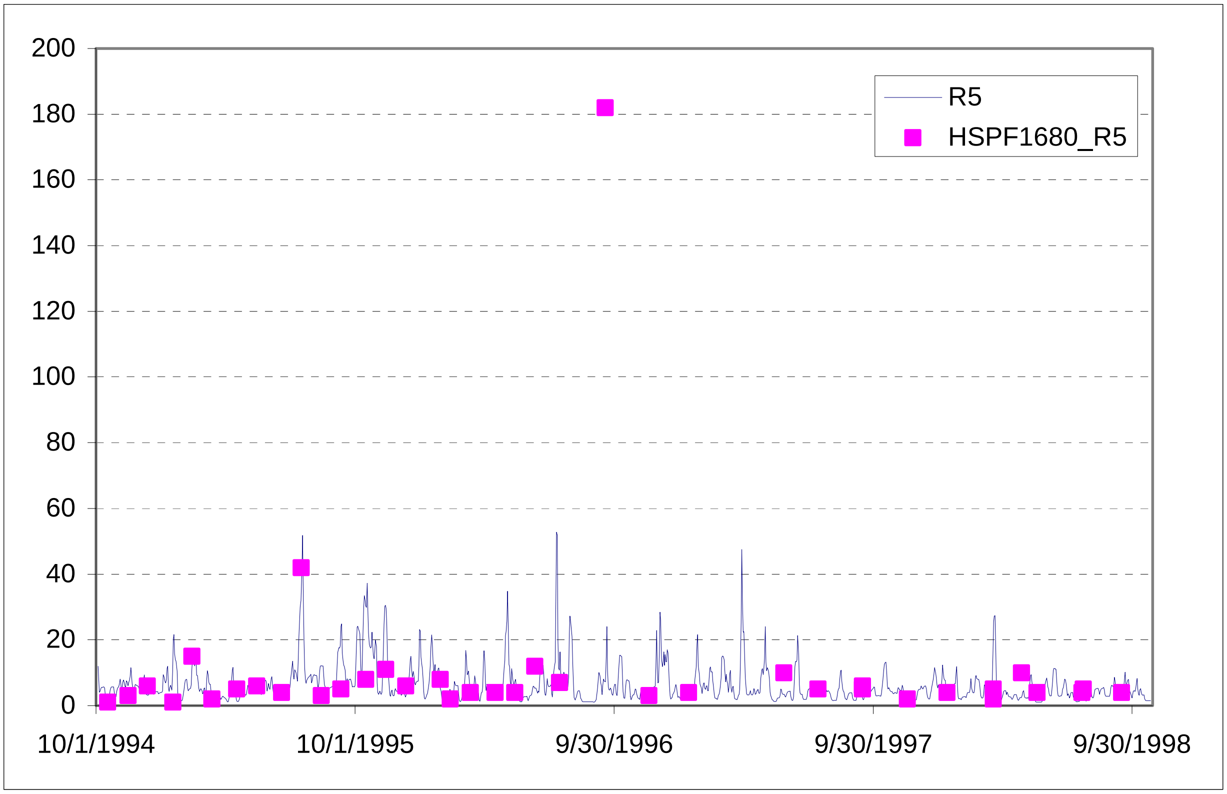
18
16
14
12
10
8
6
4
2
0
R1
AtScarletRoad_R1
10/1/1994
10/1/1995
9/30/1996
9/30/1997
9/30/1998



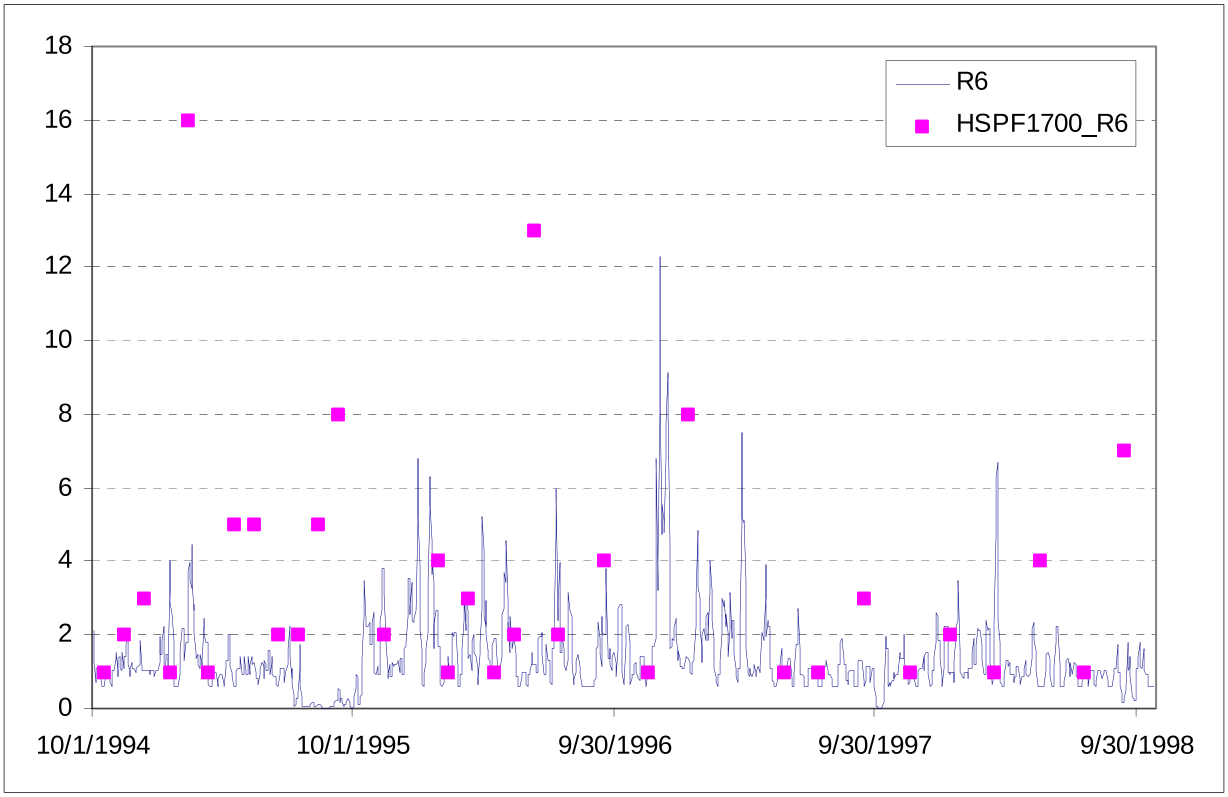
60
50
40
30
20
10
0
R2
USGSWQN150_R2
10/1/1994
10/1/1995
9/30/1996
9/30/1997
9/30/1998


35
30
25
20
15
10
5
0
10/1/1994
10/1/1995
9/30/1996
9/30/1997
9/30/1998
R3
AtRoute82_R3

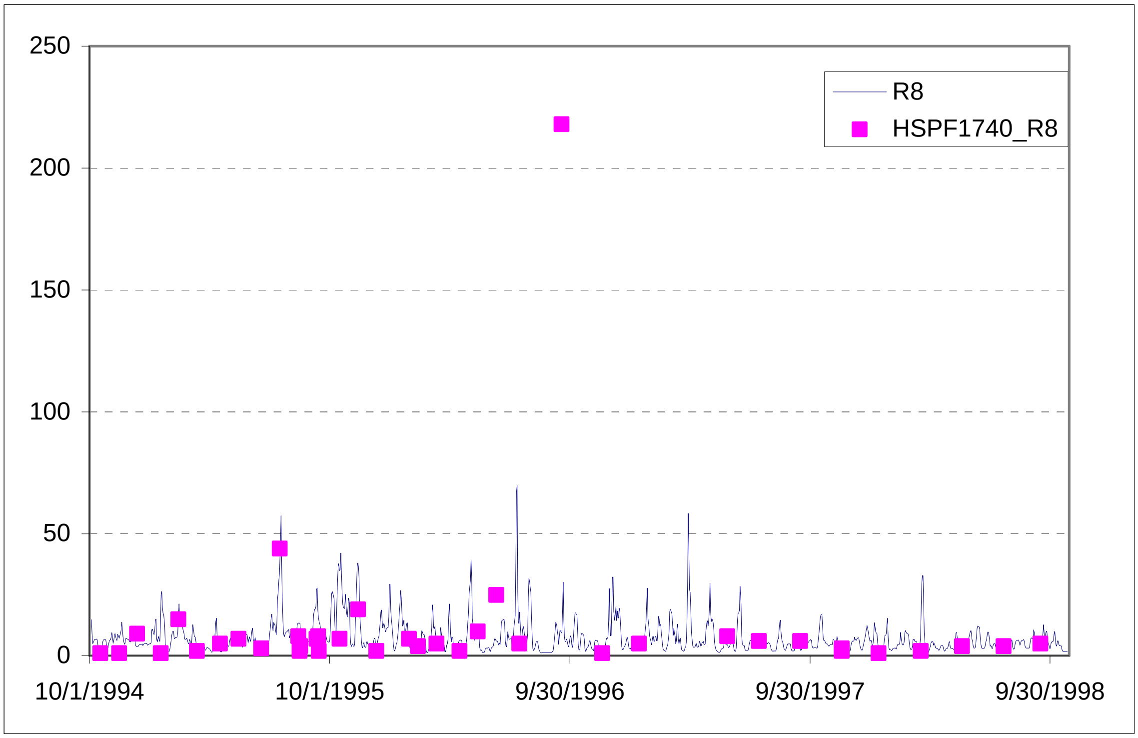

140
120
100
80
60
40
20
0
10/1/1994
10/1/1995
9/30/1996
9/30/1997
9/30/1998
R4
HSPF1660_R4



200
180
160
140
120
100
80
60
40
20
0
10/1/1994
10/1/1995
9/30/1996
9/30/1997
9/30/1998
R5
HSPF1680_R5



18
16
14
12
10
8
6
4
2
0
10/1/1994
10/1/1995
9/30/1996
9/30/1997
9/30/1998
R6
HSPF1700_R6



250
200
150
100
50
0
10/1/1994
10/1/1995
9/30/1996
9/30/1997
9/30/1998
R8
HSPF1740_R8

Appendix I

EFDC Model Enterococci Bacteria Simulation

Time-series Calibration Results

The EFDC model enterococci calibration is presented as model-data time-series graphics over the simulation period (10/1/1994 to 10/1/1998). The time-series calibration plots are shown for the six monitoring stations listed in Table I-1. See Figure K-0 for locations of these stations. The model results are daily average values and the field observations are grab samples monitored at approximately monthly intervals.

Table I-1. Monitoring stations used for EFDC model calibration of enterococci bacteria

Monitoring Station	EFDC grid cell [I,J]	Description
104011	[54,20]	Brandywine Creek, footbridge in Brandywine Park
106281	[43,55]	Little Mill Creek at Atlantic Avenue
106291	[55,13]	Christina River, railroad bridge near Port of Wilmington
106011	[53,13]	Christina River at US Rt. 13, Third Street bridge
106021	[47,13]	Christina River, Rt. 141 drawbridge in Newport, DE
106031	[34,13]	Christina River at Smalleys Dam

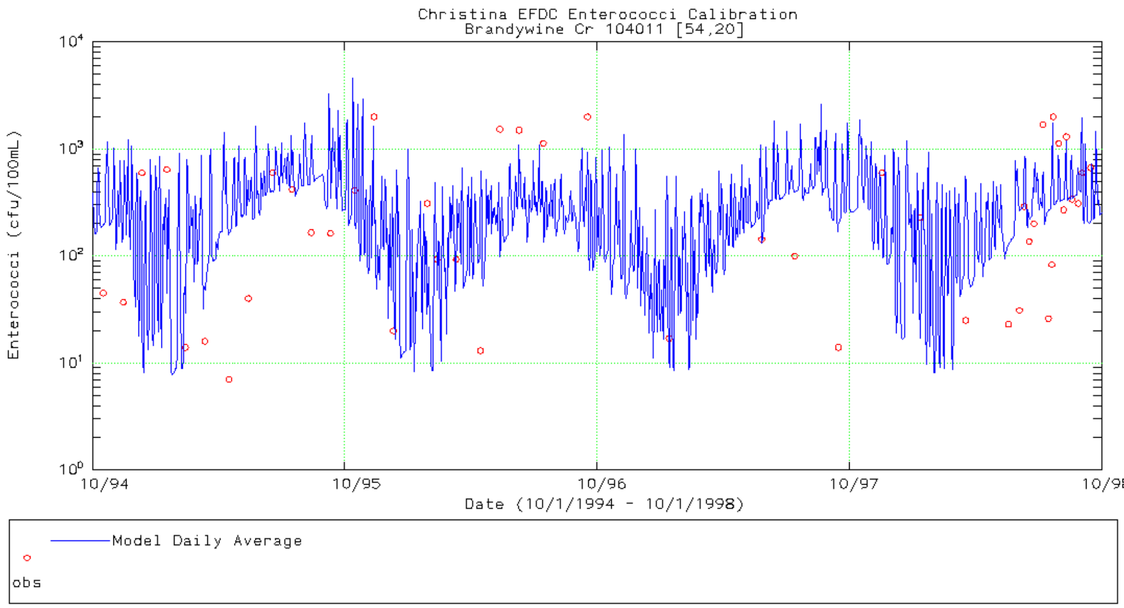


Figure I-1. EFDC model enterococci calibration, Brandywine Cr., sta 104011

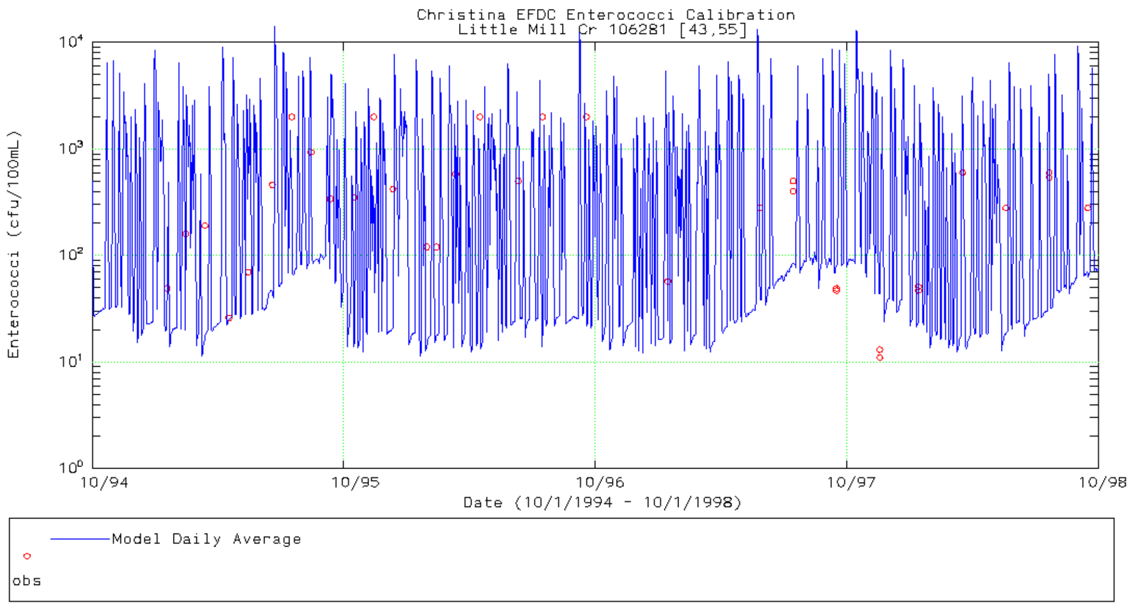


Figure I-2. EFDC model enterococci calibration, Little Mill Cr., sta 106281

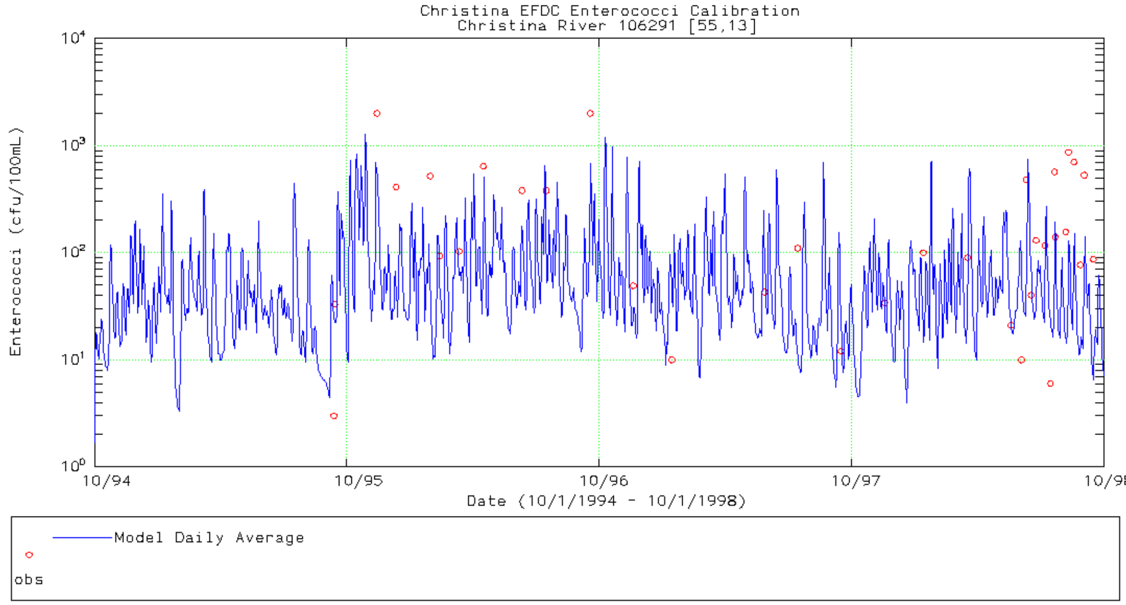


Figure I-3. EFDC model enterococci calibration, Christina River, sta 106291

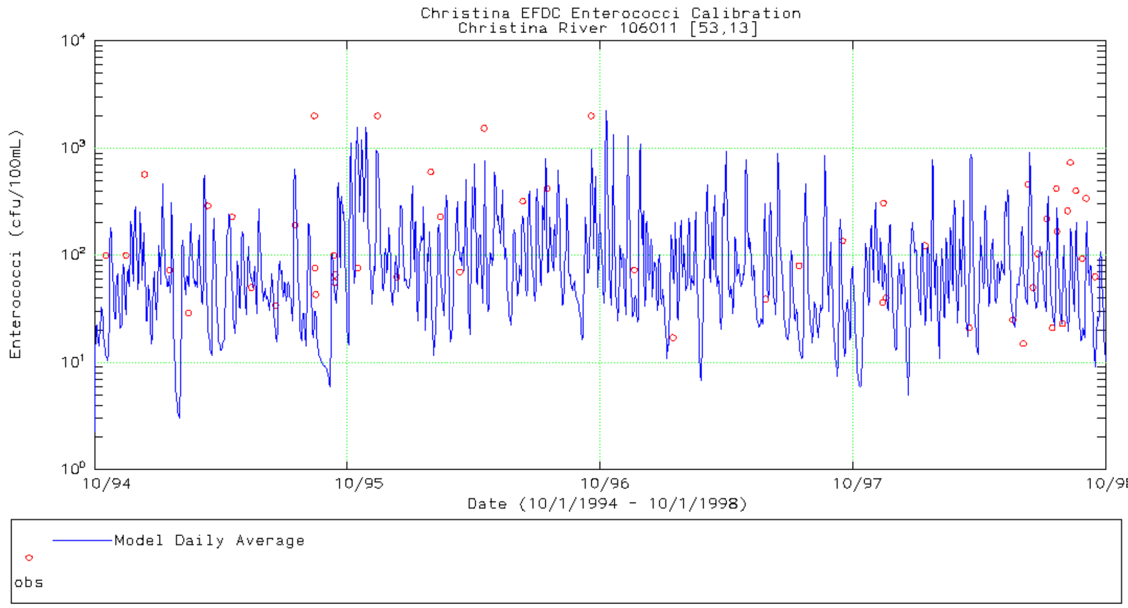


Figure I-4. EFDC model enterococci calibration, Christina River, sta 106011

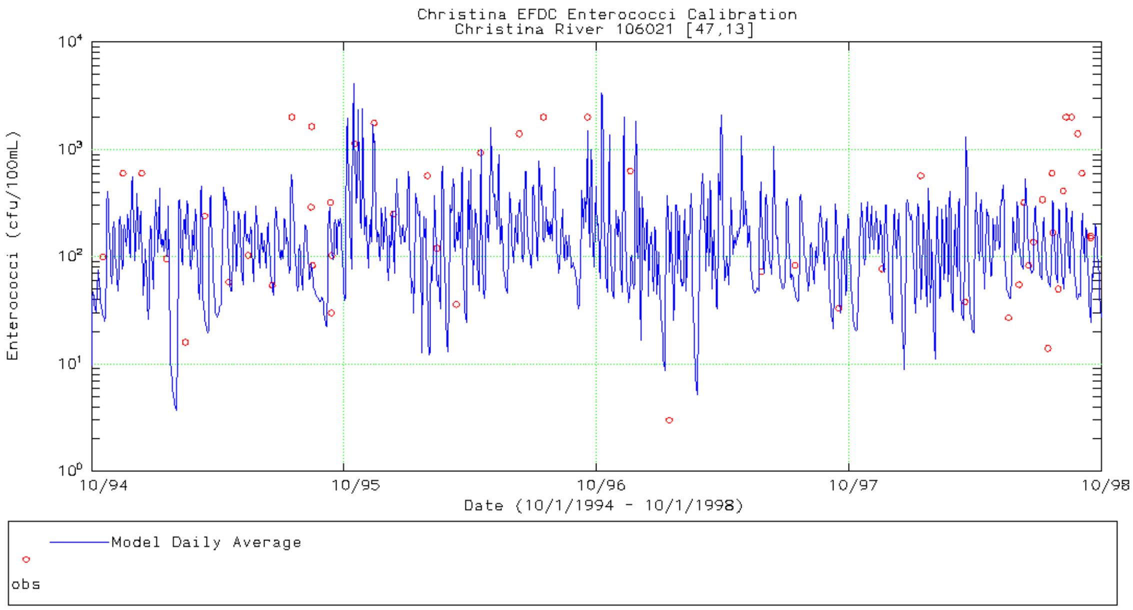


Figure I-5. EFDC model enterococci calibration, Christina River, sta 106021

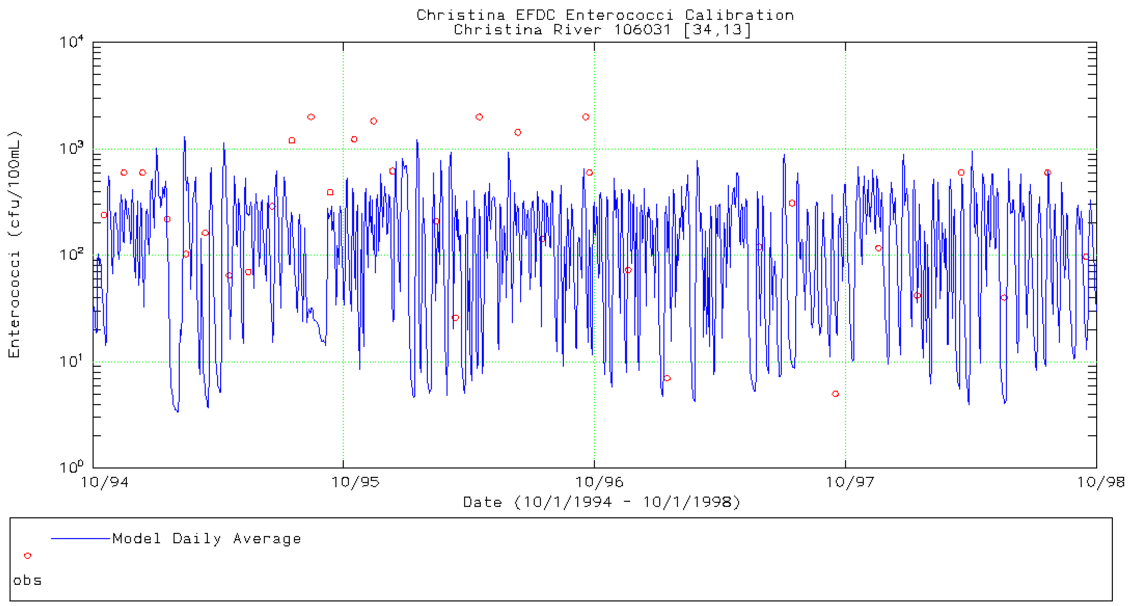


Figure I-6. EFDC model enterococci calibration, Christina River, sta 106031

Appendix J

Fecal Coliform and Enterococci Bacteria Calibration

Model-Data Time-series Comparisons with Rainfall Hyetograph

In this appendix, the HSPF model fecal coliform and enterococci bacteria calibration is presented as model-data time series graphics (Figures J-1 to J-5) for the six stations listed in Table J-1 and shown in Figure J-0. Also, a time-series graphic for station 106011 showing model-data calibration for the EFDC model at grid cell [53,13] is shown in Figure J-6. A rainfall hyetograph is superimposed on each graphic. The model data are daily average values and the observed data are grab samples.

Table J-1. Monitoring stations used for model calibration of fecal coliform and enterococci

Monitoring Station	HSPF Subbasin	Description
01480617	B05	West Branch Brandywine Creek at Modena, PA (fecal coliform)
104021	B19	Brandywine Creek at Rt. 279 bridge (enterococci)
105151	W12	White Clay Creek near Newark, DE (enterococci)
WQN0150	R02	Red Clay Creek near Kennett Square, PA (enterococci)
106141	C03	Christina River at Rt. 26, Old Baltimore Pike (enterococci)
Monitoring Station	**EFDC grid Cell [I,J]**	**Description**
106011	[53,13]	Christina River at US Rt. 13, Third Street bridge (enterococci)

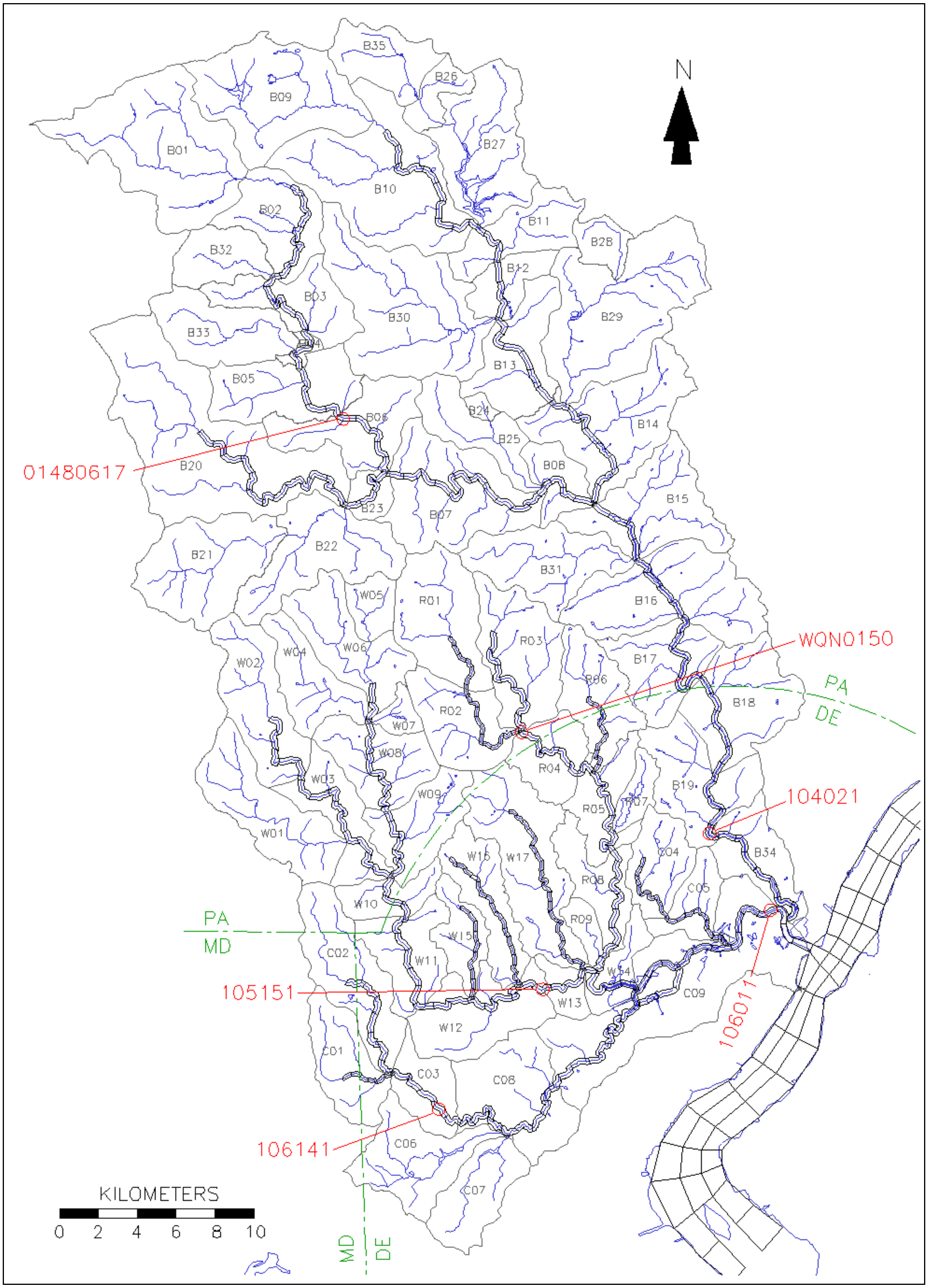


Figure J-0. Monitoring station locations used for time-series comparisons.

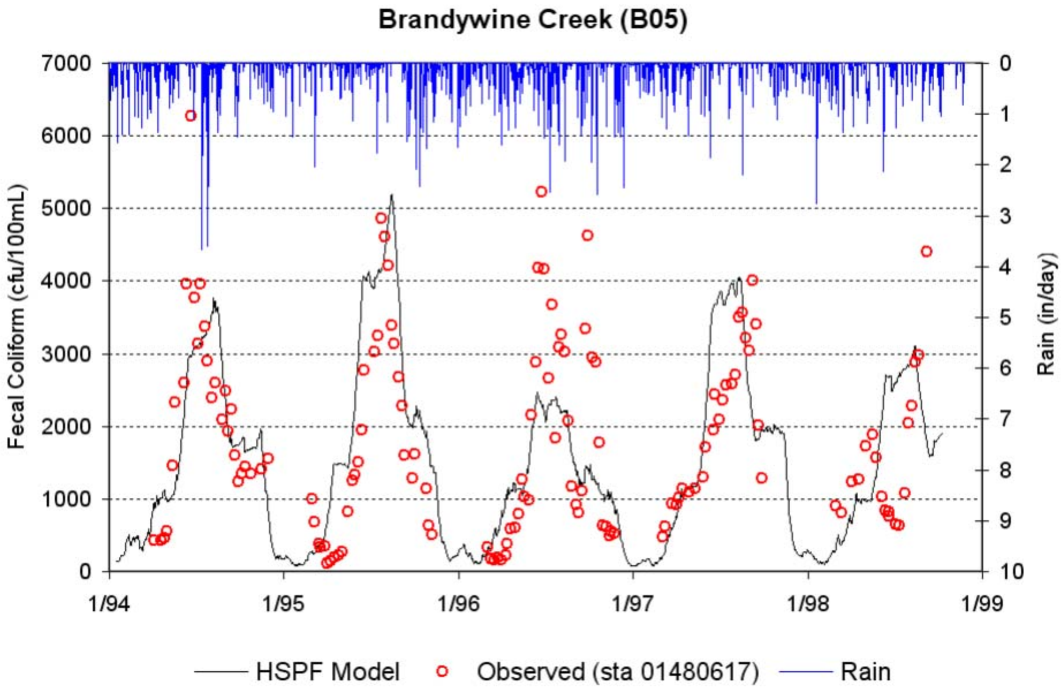


Figure J-1. Brandywine Creek, subbasin B05, station 01480617 (model results are running 30-day geometric mean and observed data are 30-day geometric mean)

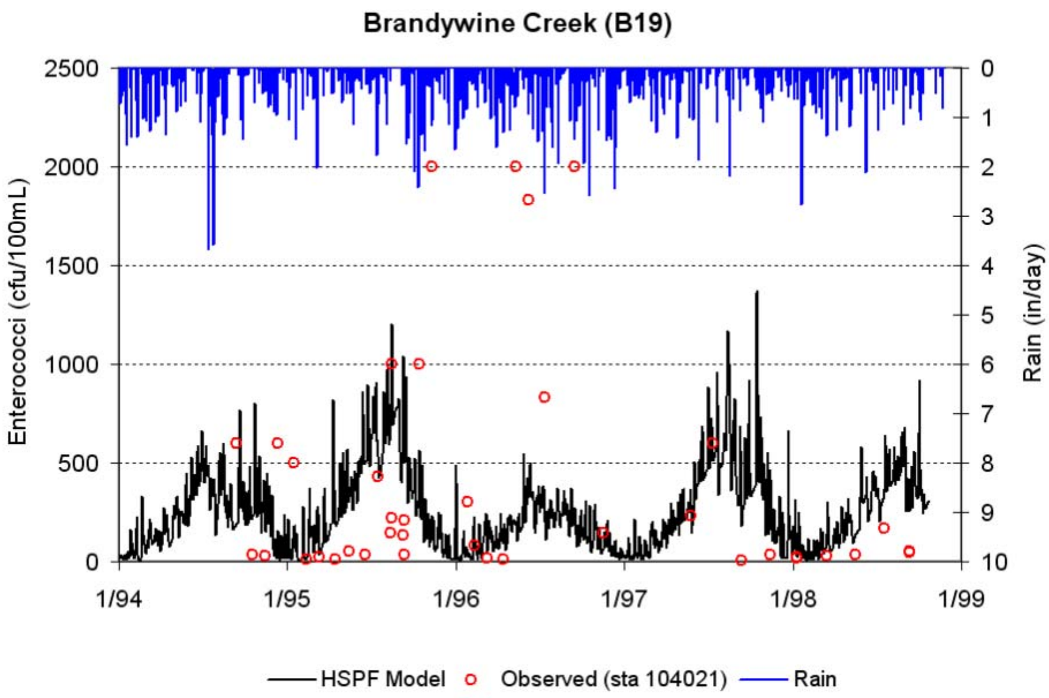


Figure J-2. Brandywine Creek, subbasin B19, station 104021 (model results are daily average and observed data are grab samples)

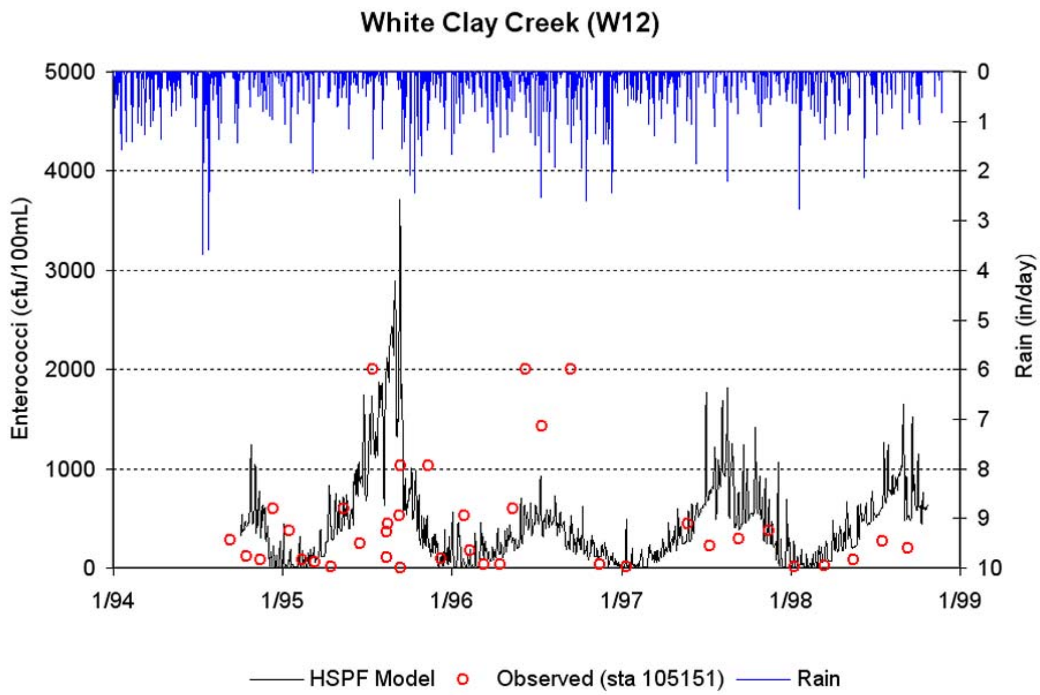


Figure J-3. White Clay Creek, subbasin W12, station 105151 (model results are daily average and observed data are grab samples)

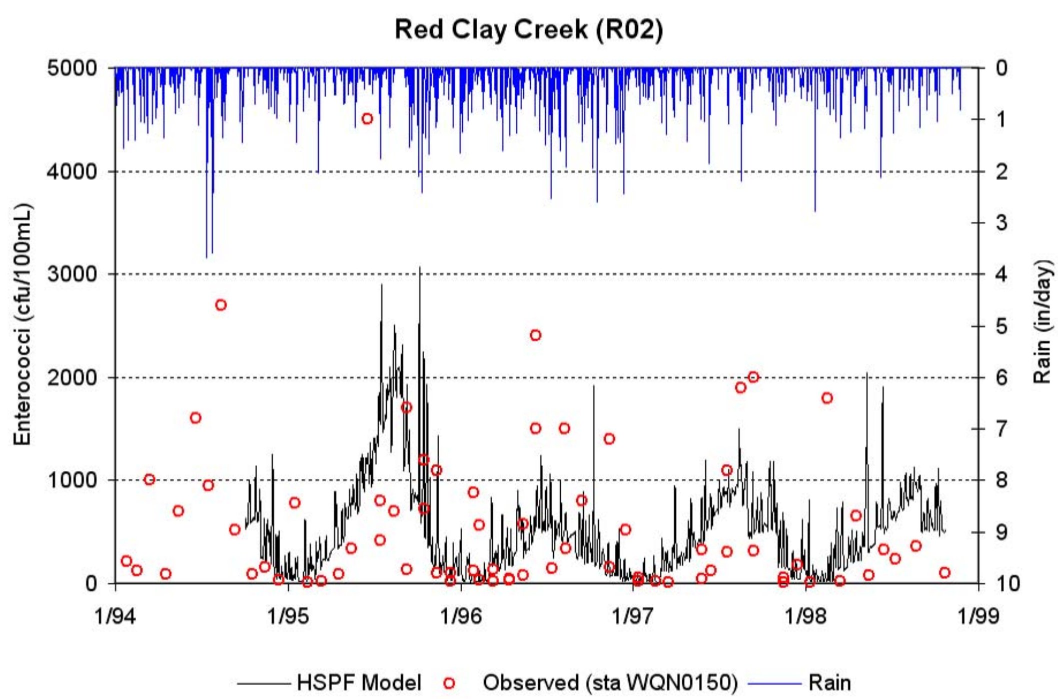


Figure J-4. Red Clay Creek, subbasin R02, station WQN0150 (model results are daily average and observed data are grab samples)

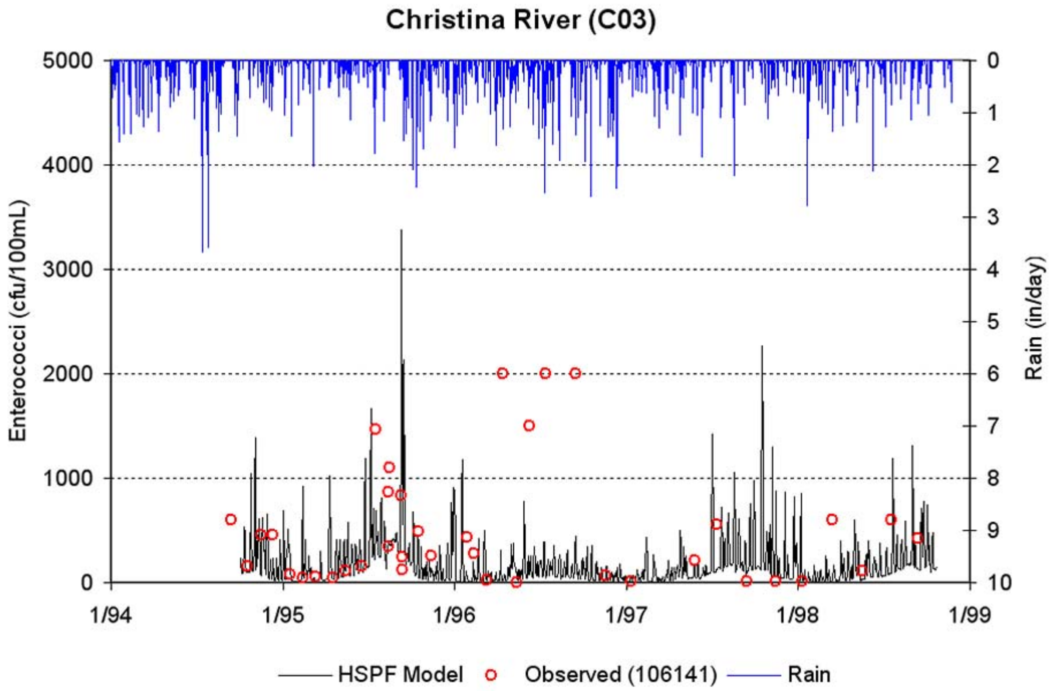


Figure J-5. Christina River, subbasin C03, station 106141 (model results are daily average and observed data are grab samples)

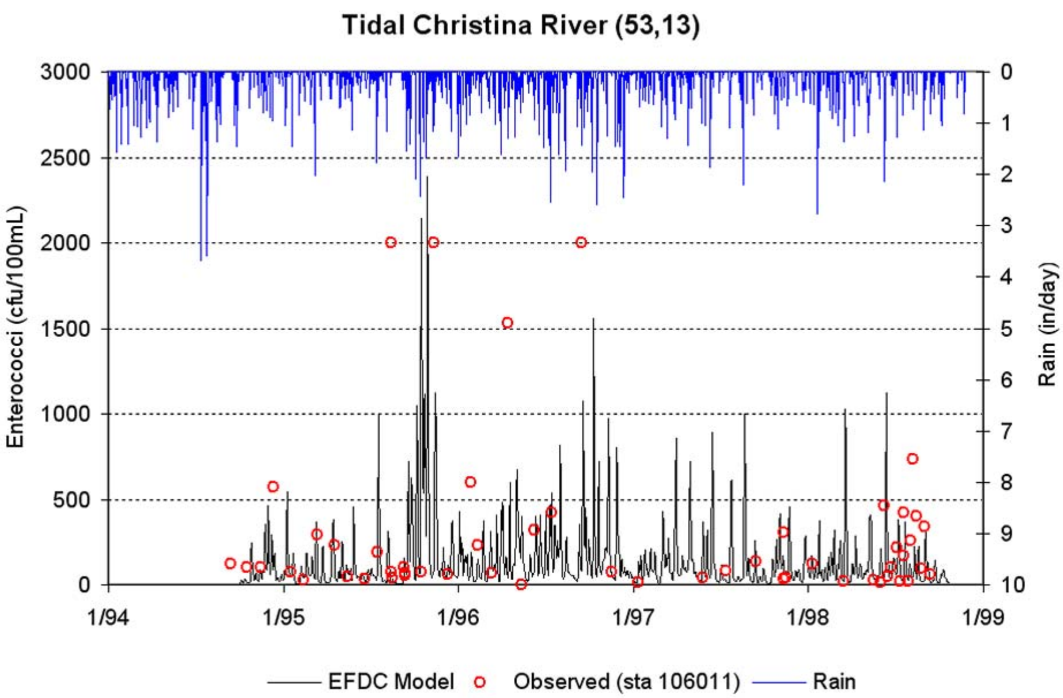


Figure J-6. Tidal Christina River, EFDC grid cell (53,13), station 106011 (model results are daily average and observed data are grab samples)

Appendix K

Bacteria Calibration

Model-Data Cumulative Probability Comparisons

In this appendix, the HSPF model fecal coliform and enterococci calibrations are presented as model-data probability distributions (Figures K-1 to K-5) for the five stations listed in Table K-1 and shown in Figure K-0.

Table K-1. Monitoring stations used for HSPF model calibration of bacteria

Monitoring Station	HSPF Subbasin	Description
01480617	B05	West Branch Brandywine Creek at Modena, PA (fecal coliform)
104021	B19	Brandywine Creek at Rt. 279 bridge (enterococci)
105151	W12	White Clay Creek near Newark, DE (enterococci)
WQN0150	R02	Red Clay Creek near Kennett Square, PA (enterococci)
106141	C03	Christina River at Rt. 26, Old Baltimore Pike (enterococci)

The EFDC model enterococci calibrations are presented as model-data probability distributions (Figures K-6 to K-11) for the six stations listed in Table K-2 and shown in Figure K-0.

Table K-2. Monitoring stations used for EFDC model calibration of enterococci bacteria

Monitoring Station	EFDC grid cell [I,J]	Description
104011	[54,20]	Brandywine Creek, footbridge in Brandywine Park
106281	[43,55]	Little Mill Creek at Atlantic Avenue
106291	[55,13]	Christina River, railroad bridge near Port of Wilmington
106011	[53,13]	Christina River at US Rt. 13, Third Street bridge
106021	[47,13]	Christina River, Rt. 141 drawbridge in Newport, DE
106031	[34,13]	Christina River at Smalleys Dam

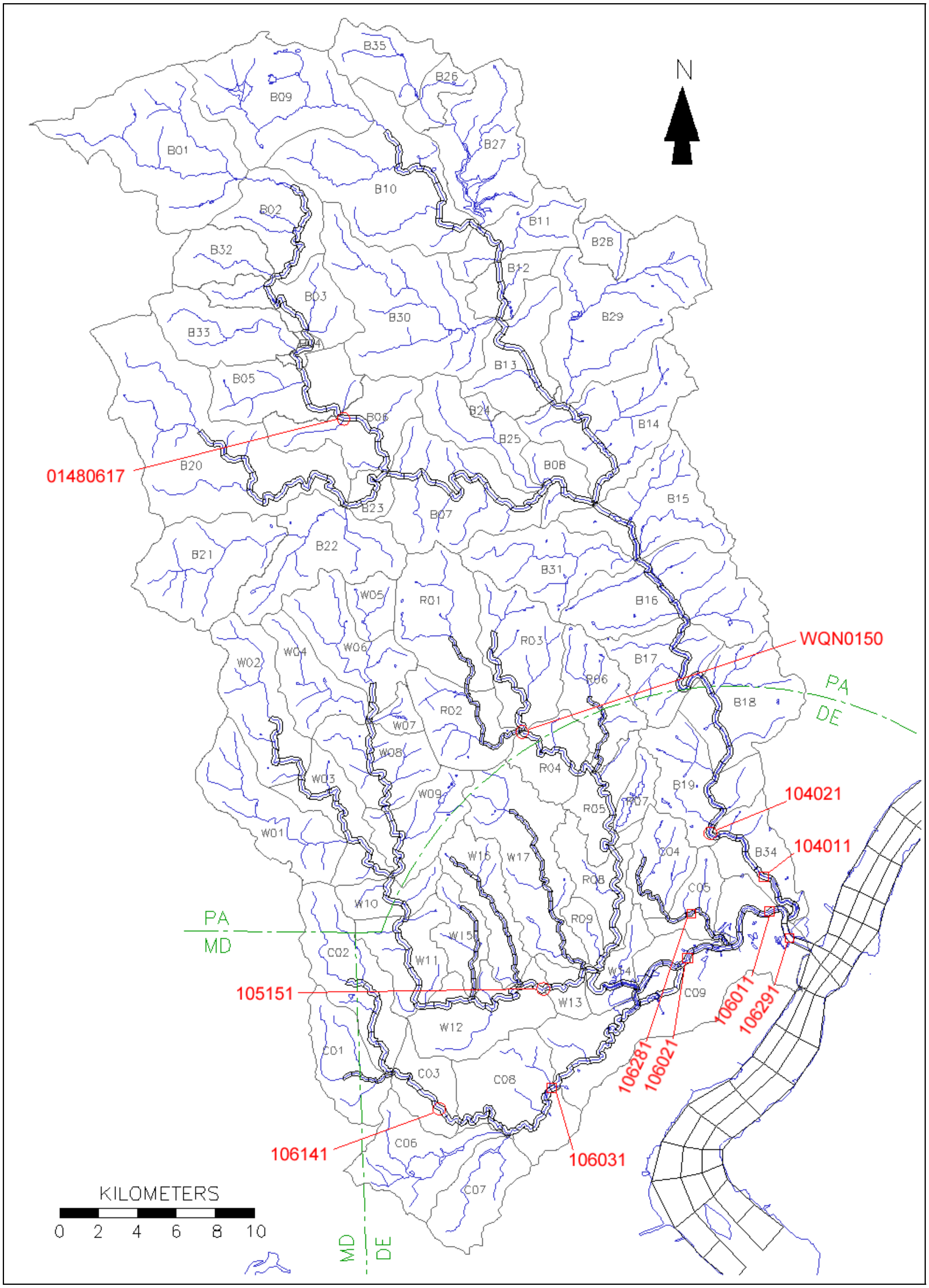


Figure K-0. Monitoring station locations used for cumulative probability analysis.

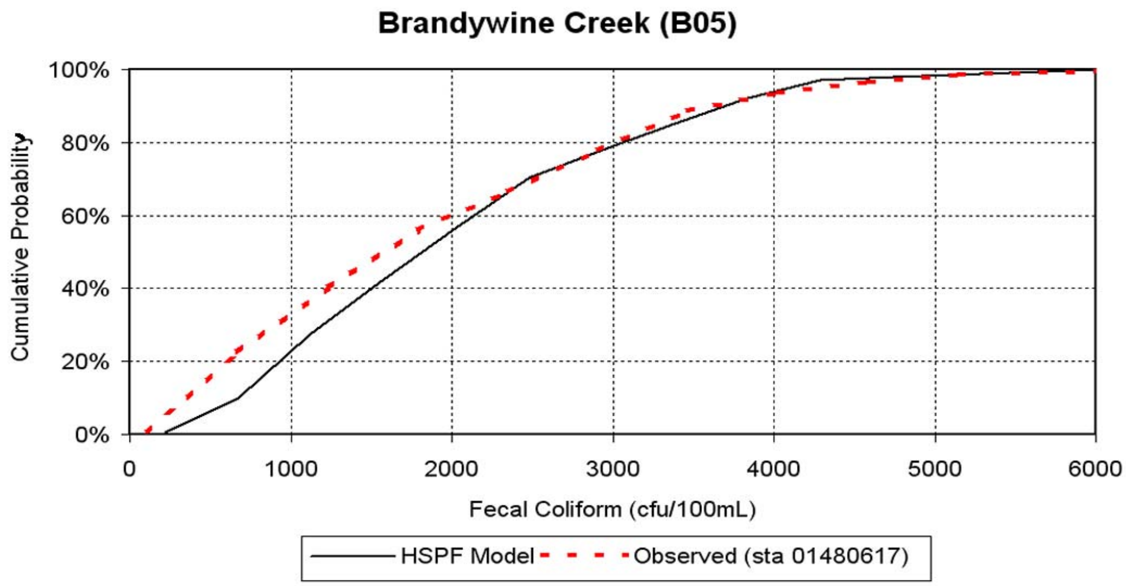


Figure K-1. HSPF model enterococci results, Brandywine Cr., subbasin B05, sta 01480617

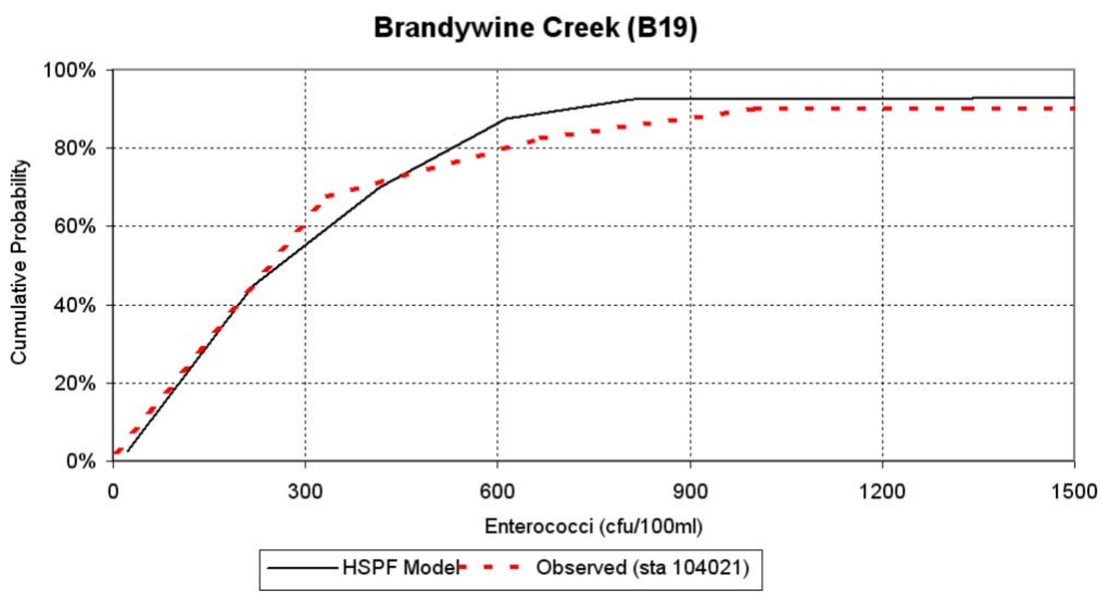


Figure K-2. HSPF model enterococci results, Brandywine Creek, subbasin B19, sta 104021

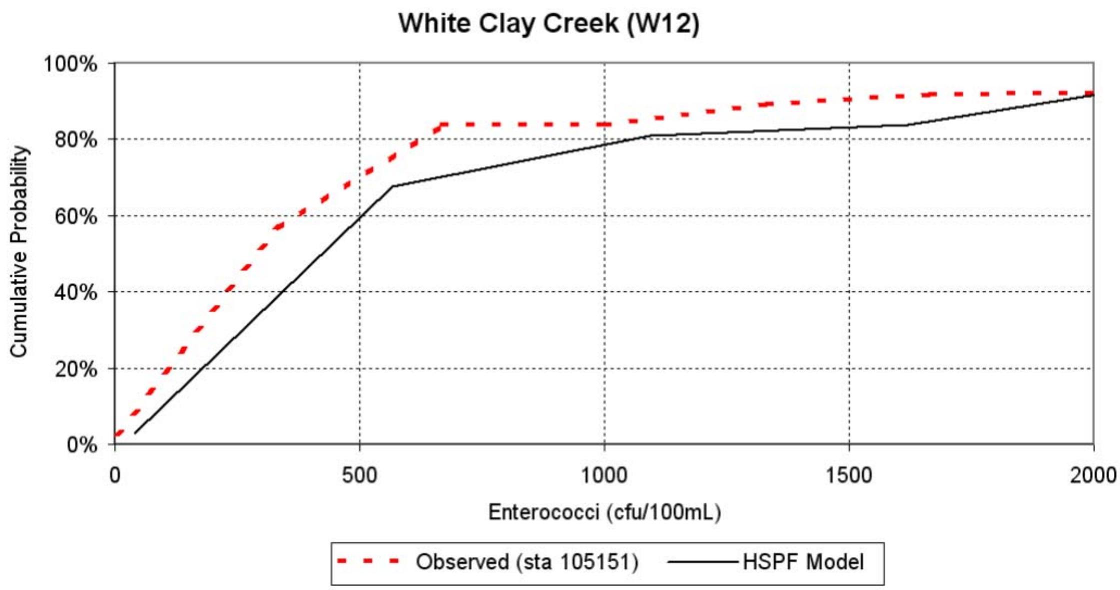


Figure K-3. HSPF model enterococci results, White Clay Creek, subbasin W12, sta 105151

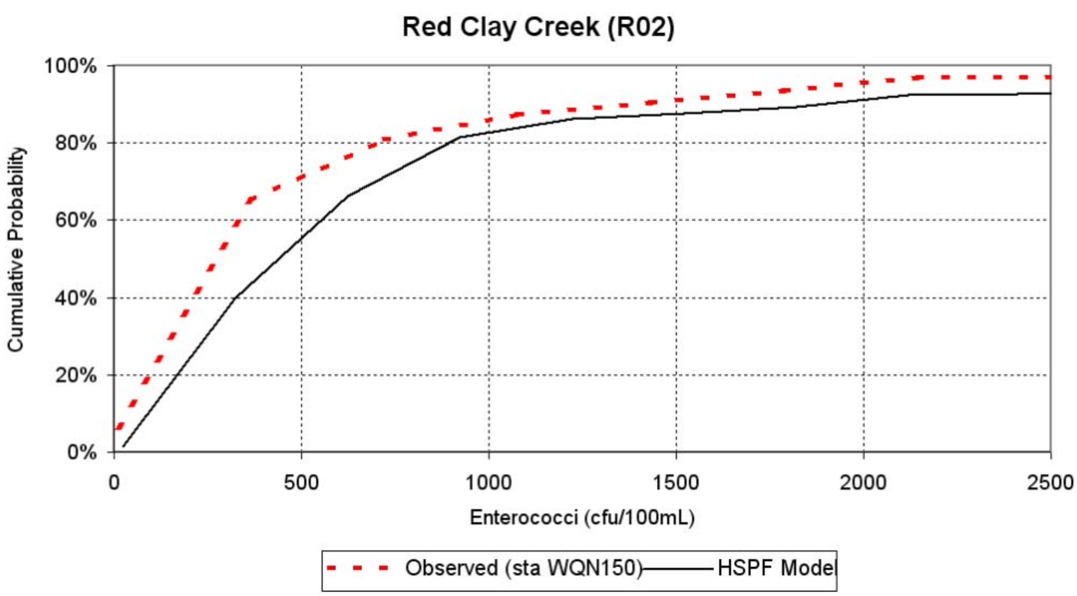


Figure K-4. HSPF model enterococci results, Red Clay Creek, subbasin R02, sta WQN0150

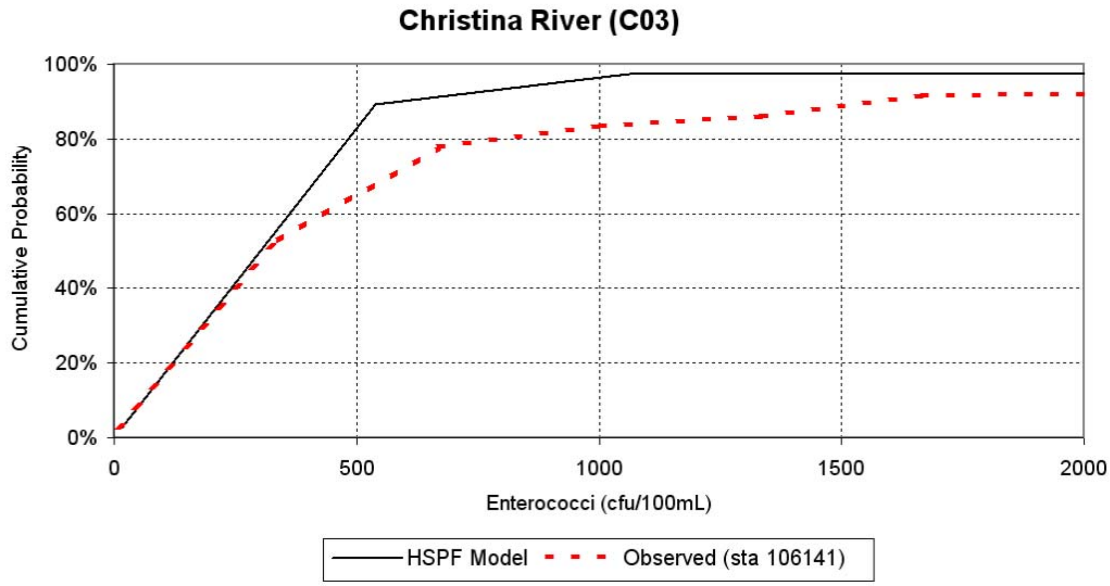


Figure K-5. HSPF model enterococci results, Christina River, subbasin C03, sta 106141

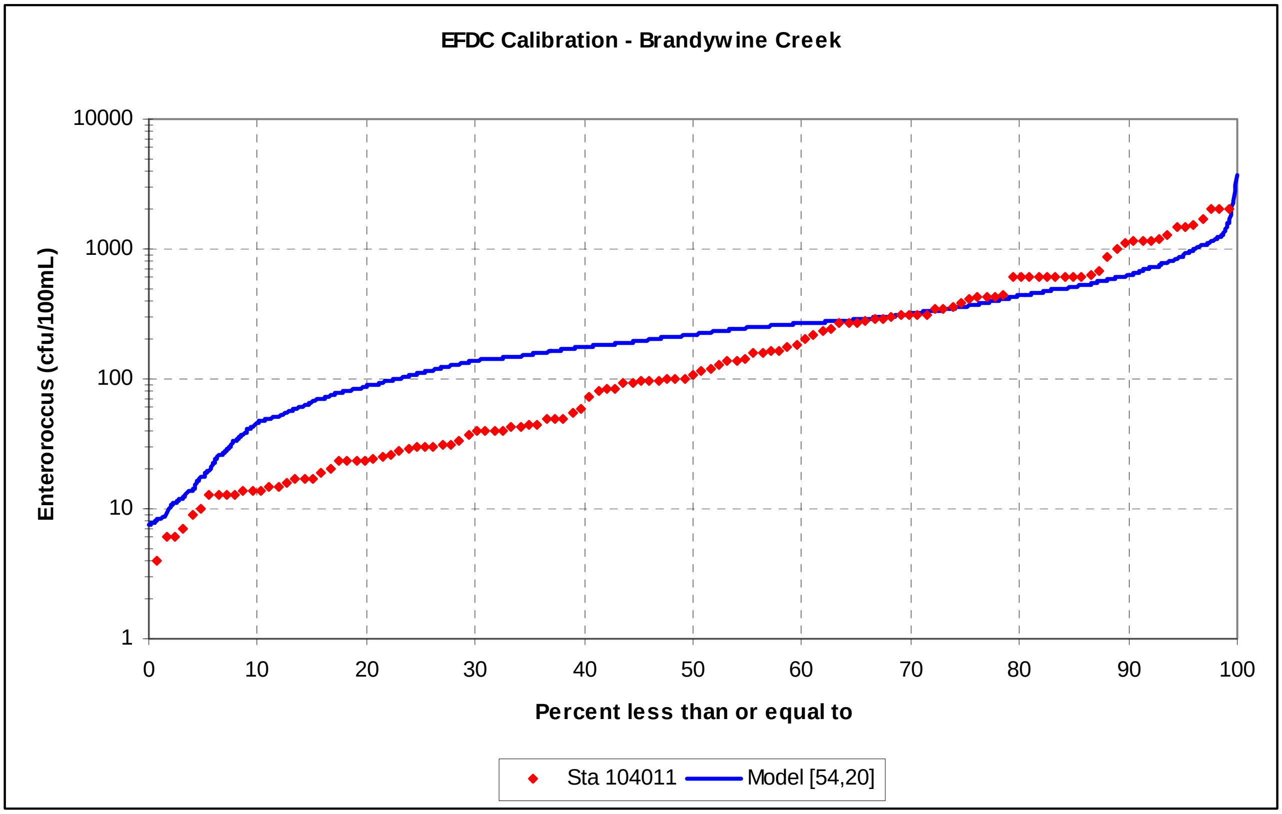


Figure K-6. EFDC model-data probability distribution at station 104011, Brandywine Creek

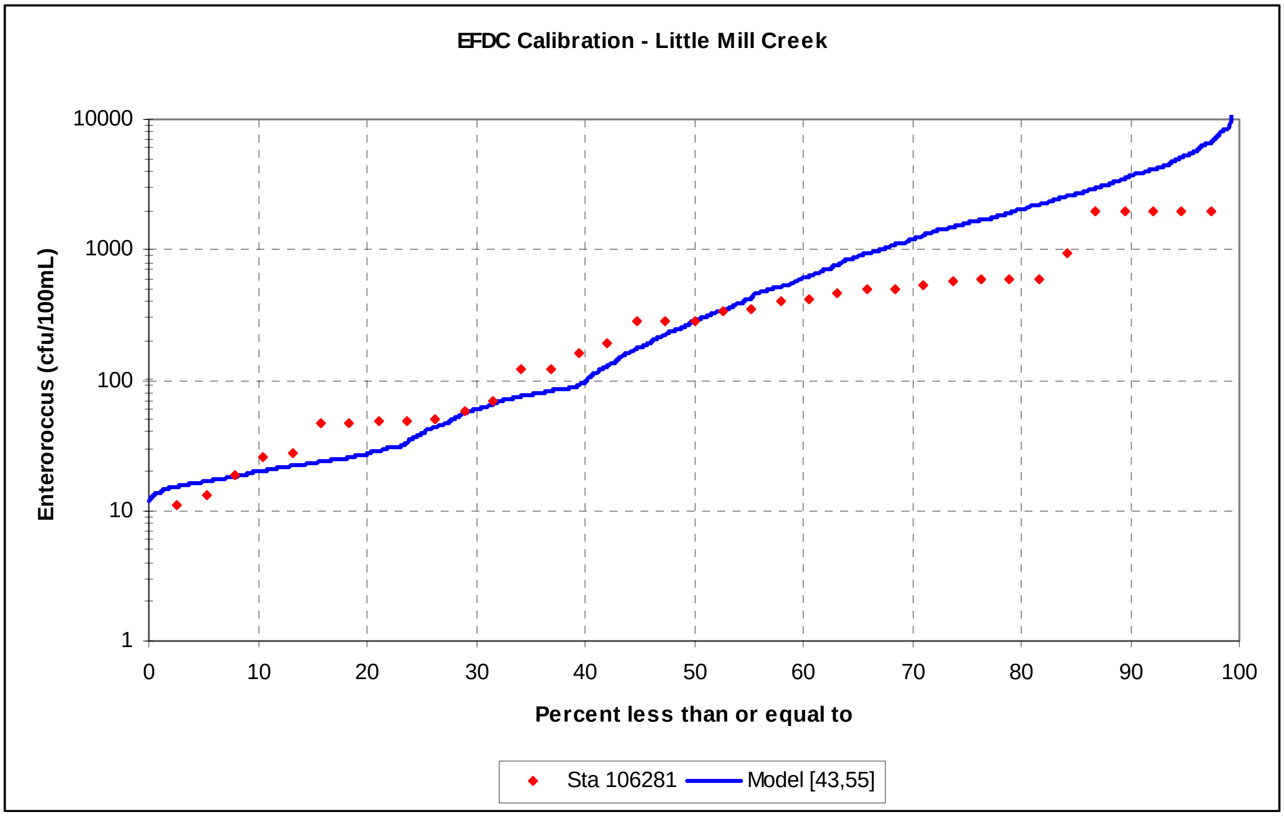


Figure K-7. EFDC model-data probability distribution at station 106281, Little Mill Creek

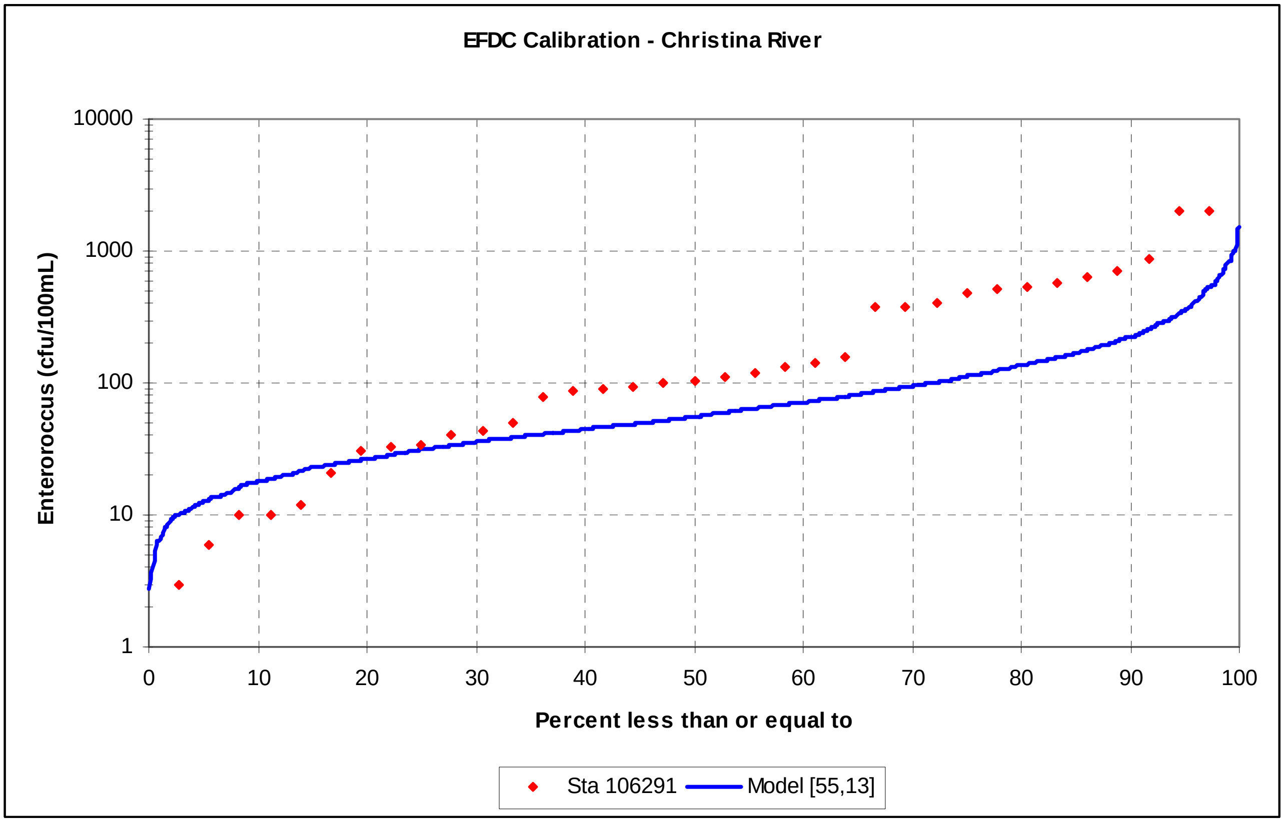


Figure K-8. EFDC model-data probability distribution at station 106291, Christina River

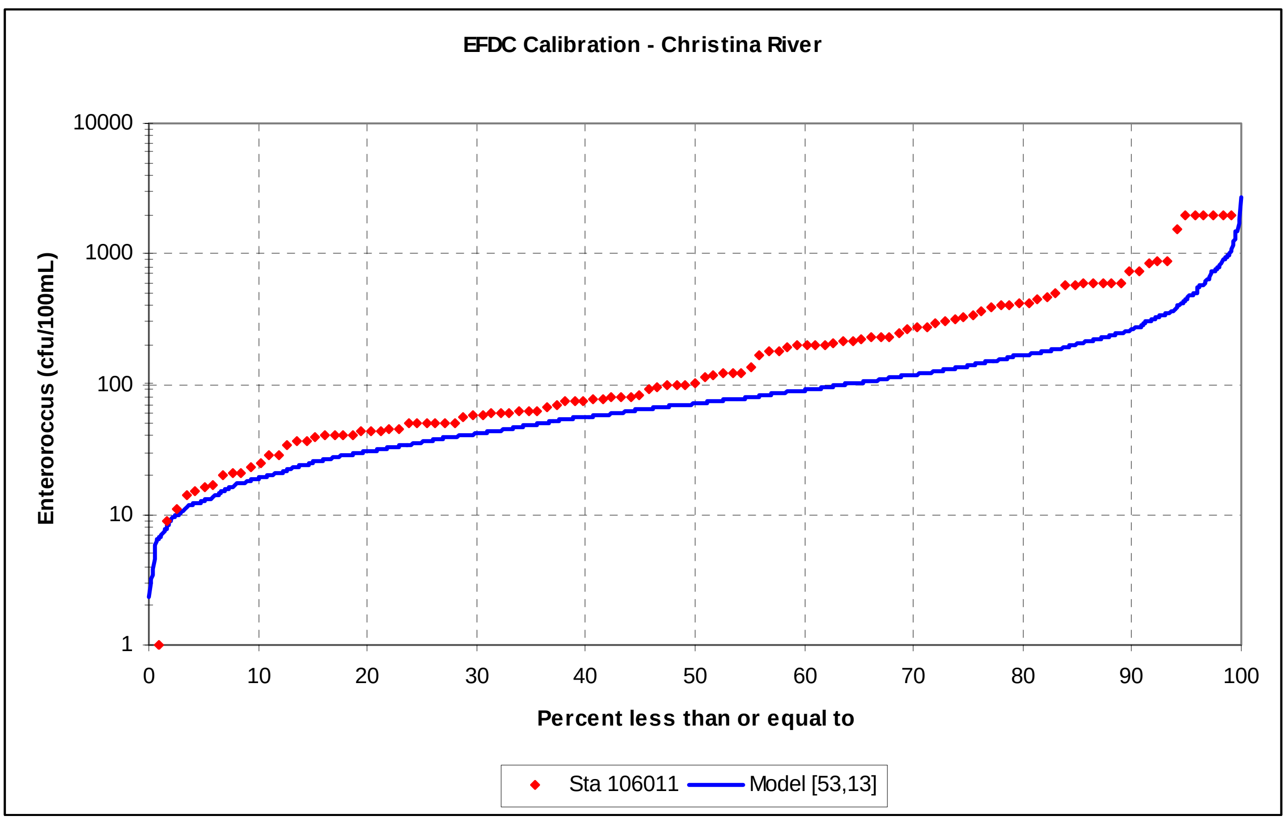


Figure K-9. EFDC model-data probability distribution at station 106011, Christina River

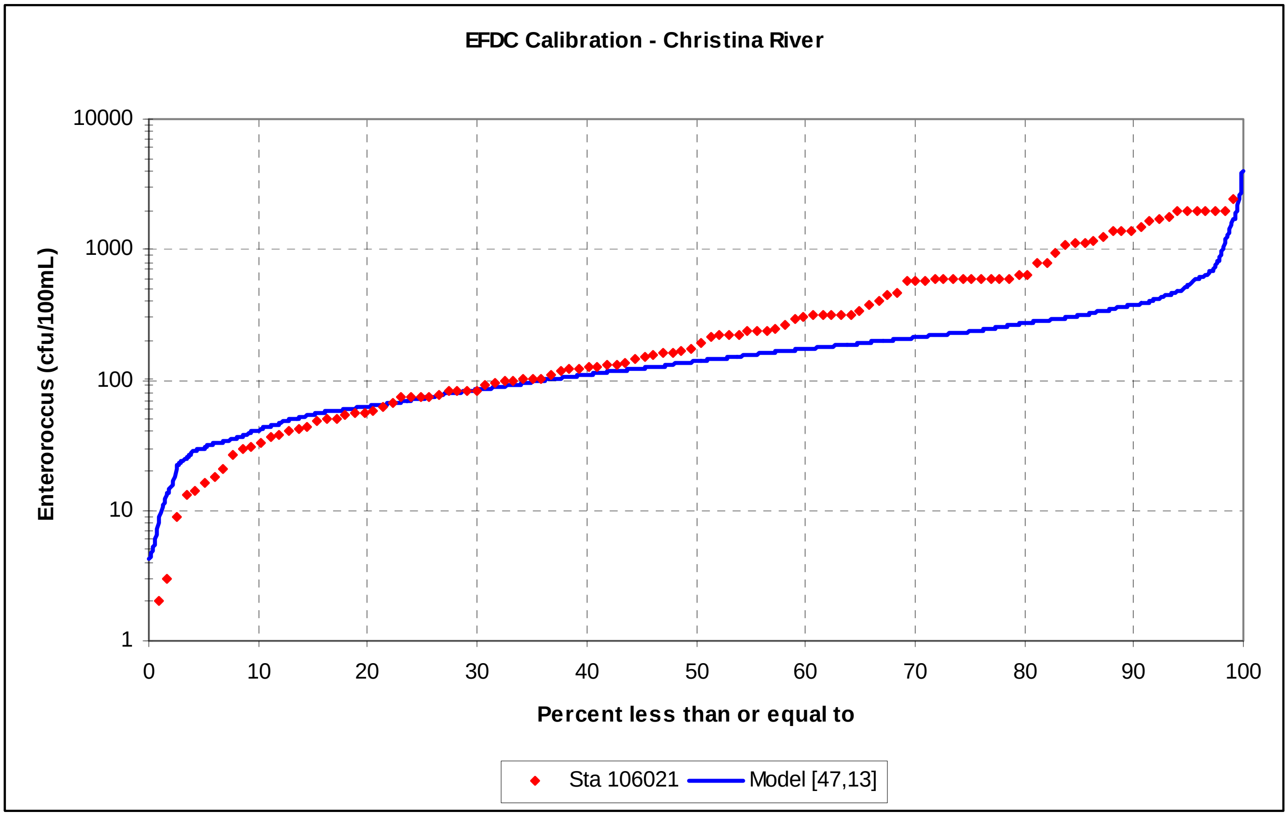


Figure K-10. EFDC model-data probability distribution at station 106021, Christina River

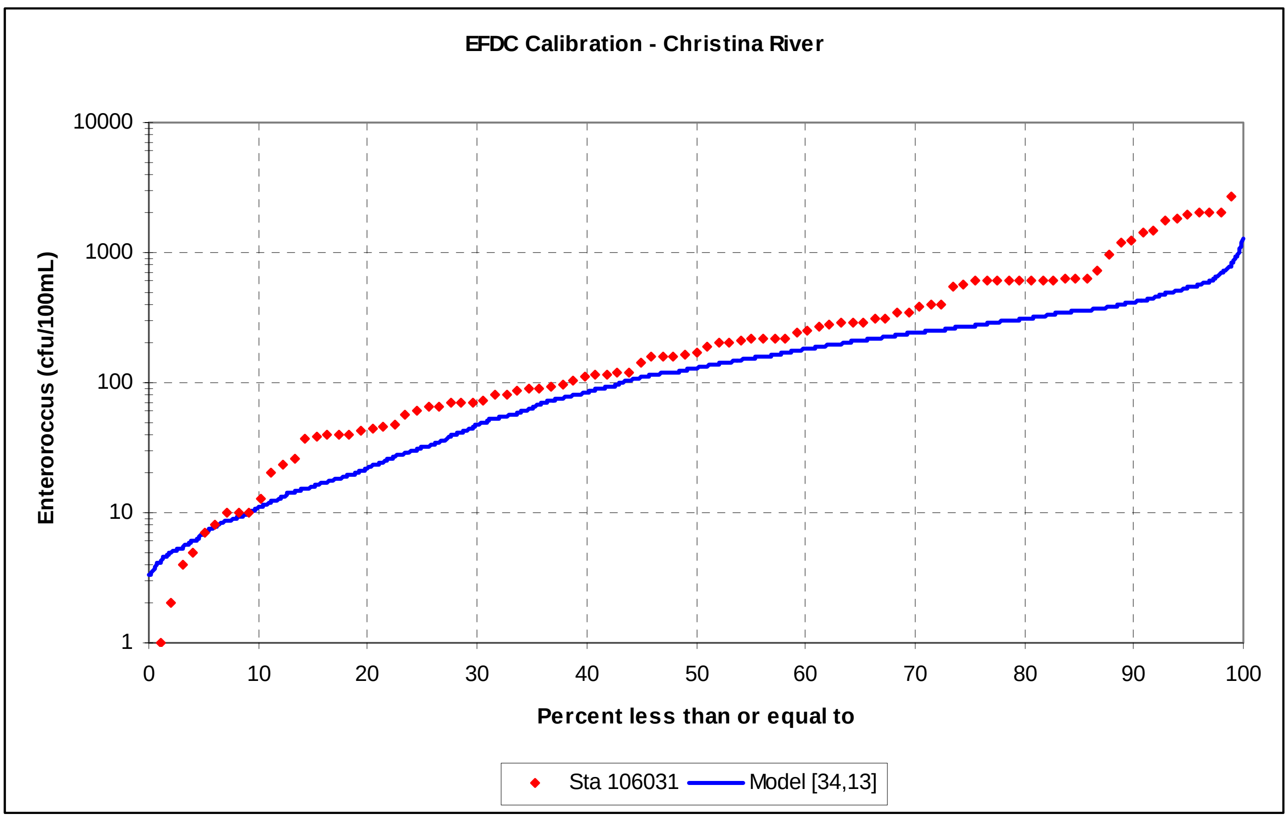


Figure K-11. EFDC model-data probability distribution at station 106031, Christina River

Appendix L

Land Use Areas for MS4 Municipalities in Chester County, PA and New Castle County, DE

Table L-1. Land Use Areas (acres) for MS4 Municipalities in Brandywine Creek Watershed

HSPF Subbasin	MS4 Municipality	Residential	Agriculture	Open Land	Forest	Water	Urban	MS4 Total	Subbasin Total	MS4 Ratio
B01	HONEY BROOK BORO	175.55	117.03	0.00	0.00	0.00	19.51	312.08	11766.82	0.0265
B01	HONEY BROOK TWP	429.11	6612.23	0.00	1501.89	19.51	370.60	8933.33	11766.82	0.7592
B01	WEST CALN TWP	78.02	0.00	0.00	370.60	0.00	19.51	468.12	11766.82	0.0398
B02	HONEY BROOK TWP	253.57	78.02	0.00	819.21	0.00	19.51	1170.31	4720.88	0.2479
B02	WEST BRANDYWINE TWP	448.62	663.17	0.00	741.19	19.51	78.02	1950.51	4720.88	0.4132
B02	WEST CALN TWP	351.09	624.16	19.51	585.15	19.51	19.51	1618.92	4720.88	0.3429
B03	COATESVILLE CITY	0.00	0.00	0.00	39.01	0.00	0.00	39.01	4324.94	0.0090
B03	VALLEY TWP	19.51	58.52	0.00	58.52	0.00	58.52	195.05	4324.94	0.0451
B03	WEST BRANDYWINE TWP	760.70	702.18	0.00	663.17	0.00	19.51	2145.56	4324.94	0.4961
B03	WEST CALN TWP	253.57	487.63	19.51	643.67	19.51	39.01	1462.88	4324.94	0.3382
B04	COATESVILLE CITY	19.51	0.00	0.00	175.55	0.00	39.01	234.06	519.99	0.4501
B04	VALLEY TWP	19.51	39.01	0.00	234.06	0.00	19.51	312.08	519.99	0.6002
B05	COATESVILLE CITY	487.63	0.00	19.51	117.03	0.00	312.08	936.24	5644.14	0.1659
B05	EAST FALLOWFIELD TWP	136.54	331.59	0.00	565.65	0.00	156.04	1189.81	5644.14	0.2108
B05	MODENA BORO	19.51	0.00	0.00	39.01	19.51	0.00	78.02	5644.14	0.0138
B05	SADSBURY TWP	19.51	58.52	0.00	19.51	0.00	19.51	117.03	5644.14	0.0207
B05	VALLEY TWP	331.59	585.15	19.51	604.66	19.51	468.12	2028.53	5644.14	0.3594
B06	EAST FALLOWFIELD TWP	916.74	1404.37	39.01	1443.38	0.00	136.54	3940.03	5159.73	0.7636
B06	MODENA BORO	19.51	39.01	0.00	39.01	0.00	58.52	156.04	5159.73	0.0302
B06	NEWLIN TWP	0.00	58.52	0.00	175.55	0.00	39.01	273.07	5159.73	0.0529
B06	WEST BRADFORD TWP	136.54	351.09	0.00	234.06	0.00	0.00	721.69	5159.73	0.1399
B07	EAST MARLBOROUGH TWP	39.01	429.11	0.00	156.04	0.00	0.00	624.16	8616.54	0.0724
B07	NEWLIN TWP	292.58	2867.25	0.00	2594.18	97.53	273.07	6124.60	8616.54	0.7108
B07	POCOPSON TWP	39.01	195.05	0.00	117.03	0.00	19.51	370.60	8616.54	0.0430
B07	WEST BRADFORD TWP	195.05	507.13	0.00	546.14	0.00	175.55	1423.87	8616.54	0.1652
B08	EAST BRADFORD TWP	78.02	429.11	0.00	214.56	19.51	0.00	741.19	2314.42	0.3203
B08	POCOPSON TWP	0.00	526.64	0.00	195.05	19.51	0.00	741.19	2314.42	0.3203
B08	WEST BRADFORD TWP	136.54	487.63	0.00	195.05	0.00	39.01	858.22	2314.42	0.3708
B09	HONEY BROOK TWP	292.58	2711.21	0.00	916.74	273.07	39.01	4232.60	9397.55	0.4504
B09	WALLACE TWP	39.01	97.53	0.00	234.06	0.00	39.01	409.61	9397.55	0.0436
B10	EAST BRANDYWINE TWP	819.21	819.21	19.51	819.21	19.51	19.51	2516.16	11721.04	0.2147
B10	HONEY BROOK TWP	58.52	19.51	0.00	58.52	39.01	39.01	214.56	11721.04	0.0183
B10	UPPER UWCHLAN TWP	97.53	195.05	0.00	195.05	0.00	19.51	507.13	11721.04	0.0433
B10	WALLACE TWP	702.18	1794.47	58.52	2633.19	0.00	175.55	5363.90	11721.04	0.4576
B10	WEST BRANDYWINE TWP	409.61	819.21	19.51	741.19	19.51	78.02	2087.04	11721.04	0.1781
B11	EAST BRANDYWINE TWP	214.56	331.59	0.00	546.14	0.00	0.00	1092.29	4039.89	0.2704
B11	UPPER UWCHLAN TWP	0.00	19.51	0.00	78.02	0.00	0.00	97.53	4039.89	0.0241
B11	UWCHLAN TWP	663.17	916.74	39.01	936.24	0.00	253.57	2808.73	4039.89	0.6952
B12	DOWNINGTOWN BORO	156.04	39.01	39.01	39.01	19.51	58.52	351.09	2369.53	0.1482
B12	EAST BRANDYWINE TWP	156.04	58.52	0.00	136.54	19.51	19.51	390.10	2369.53	0.1646
B12	EAST CALN TWP	195.05	39.01	0.00	292.58	0.00	19.51	546.14	2369.53	0.2305
B12	UWCHLAN TWP	312.08	0.00	0.00	331.59	0.00	19.51	663.17	2369.53	0.2799

HSPF Subbasin	MS4 Municipality	Residential	Agriculture	Open Land	Forest	Water	Urban	MS4 Total	Subbasin Total	MS4 Ratio
B13	DOWNINGTOWN BORO	253.57	136.54	0.00	117.03	0.00	234.06	741.19	5084.19	0.1458
B13	EAST BRADFORD TWP	39.01	136.54	0.00	409.61	19.51	0.00	604.66	5084.19	0.1189
B13	EAST CALN TWP	273.07	234.06	117.03	351.09	0.00	214.56	1189.81	5084.19	0.2340
B13	WEST BRADFORD TWP	702.18	253.57	0.00	1404.37	0.00	156.04	2516.16	5084.19	0.4949
B14	EAST BRADFORD TWP	1072.78	1931.00	97.53	1131.30	97.53	156.04	4486.17	8268.16	0.5426
B14	WEST BRADFORD TWP	97.53	526.64	0.00	487.63	0.00	78.02	1189.81	8268.16	0.1439
B14	WEST GOSHEN TWP	663.17	214.56	19.51	838.72	19.51	195.05	1950.51	8268.16	0.2359
B15	BIRMINGHAM TWP	546.14	741.19	117.03	136.54	19.51	136.54	1696.94	6631.34	0.2559
B15	EAST BRADFORD TWP	526.64	604.66	19.51	351.09	0.00	117.03	1618.92	6631.34	0.2441
B15	PENNSBURY TWP	0.00	19.51	0.00	0.00	0.00	0.00	19.51	6631.34	0.0029
B15	POCOPSON TWP	136.54	663.17	0.00	234.06	97.53	58.52	1189.81	6631.34	0.1794
B15	THORNBURY TWP	0.00	331.59	0.00	97.53	0.00	19.51	448.62	6631.34	0.0677
B15	WEST GOSHEN TWP	253.57	0.00	58.52	78.02	0.00	19.51	409.61	6631.34	0.0618
B16	BIRMINGHAM TWP	585.15	780.20	0.00	780.20	39.01	58.52	2243.09	8996.74	0.2493
B16	KENNETT TWP	351.09	214.56	0.00	117.03	0.00	58.52	741.19	8996.74	0.0824
B16	PENNSBURY TWP	975.25	760.70	0.00	1228.82	39.01	78.02	3081.80	8996.74	0.3425
B16	THORNBURY TWP	0.00	0.00	0.00	19.51	0.00	0.00	19.51	8996.74	0.0022
B17	KENNETT TWP	78.02	0.00	0.00	58.52	0.00	0.00	136.54	4804.91	0.0284
B17	PENNSBURY TWP	370.60	936.24	0.00	1326.35	58.52	0.00	2691.70	4804.91	0.5602
B18	PENNSBURY TWP	0.00	19.51	0.00	19.51	19.51	0.00	58.52	6636.33	0.0088
B18	New Castle Co., DE	541.70	906.34	622.35	1630.53	47.00	518.45	4266.37	6636.33	0.6429
B19	Wilmington, DE	3.59	0.00	7.18	14.36	1.80	3.59	30.53	5534.18	0.0055
B19	New Castle Co., DE	1152.14	228.80	2220.40	898.84	54.03	949.45	5503.65	5534.18	0.9945
B20	EAST FALLOWFIELD TWP	585.15	2165.07	0.00	1111.79	19.51	117.03	3998.54	16344.14	0.2446
B20	HIGHLAND TWP	136.54	3744.98	0.00	1482.39	19.51	234.06	5617.47	16344.14	0.3437
B20	PARKESBURG BORO	429.11	97.53	0.00	97.53	0.00	136.54	760.70	16344.14	0.0465
B20	SADSBURY TWP	507.13	2048.03	0.00	975.25	0.00	312.08	3842.50	16344.14	0.2351
B20	WEST CALN TWP	58.52	273.07	0.00	195.05	0.00	19.51	546.14	16344.14	0.0334
B21	HIGHLAND TWP	78.02	2594.18	0.00	253.57	19.51	58.52	3003.78	7074.39	0.4246
B22	EAST FALLOWFIELD TWP	0.00	19.51	0.00	0.00	0.00	0.00	19.51	7013.14	0.0028
B22	EAST MARLBOROUGH TWP	0.00	234.06	0.00	97.53	0.00	0.00	331.59	7013.14	0.0473
B23	EAST FALLOWFIELD TWP	0.00	351.09	0.00	273.07	0.00	0.00	624.16	1245.87	0.5010
B23	NEWLIN TWP	0.00	331.59	0.00	292.58	0.00	0.00	624.16	1245.87	0.5010
B24	WEST BRADFORD TWP	390.10	19.51	0.00	0.00	0.00	0.00	409.61	383.68	1.0676
B25	NEWLIN TWP	39.01	39.01	0.00	0.00	0.00	0.00	78.02	3733.70	0.0209
B25	WEST BRADFORD TWP	936.24	1443.38	19.51	1111.79	0.00	175.55	3686.46	3733.70	0.9873
B26	WALLACE TWP	78.02	97.53	0.00	273.07	0.00	39.01	487.63	1673.35	0.2914
B27	UPPER UWCHLAN TWP	1404.37	1306.84	78.02	1599.42	565.65	273.07	5227.36	6837.84	0.7645
B27	UWCHLAN TWP	0.00	0.00	0.00	39.01	0.00	0.00	39.01	6837.84	0.0057
B27	WALLACE TWP	175.55	195.05	0.00	292.58	19.51	19.51	702.18	6837.84	0.1027
B28	UWCHLAN TWP	741.19	19.51	39.01	136.54	0.00	58.52	994.76	1537.60	0.6470
B29	EAST BRADFORD TWP	526.64	448.62	39.01	1228.82	0.00	97.53	2340.61	11653.36	0.2009
B29	EAST CALN TWP	39.01	39.01	78.02	214.56	39.01	273.07	682.68	11653.36	0.0586
B29	UWCHLAN TWP	156.04	19.51	0.00	78.02	0.00	19.51	273.07	11653.36	0.0234
B29	WEST GOSHEN TWP	409.61	78.02	0.00	195.05	0.00	39.01	721.69	11653.36	0.0619
B30	DOWNINGTOWN BORO	214.56	19.51	0.00	39.01	0.00	19.51	292.58	11568.11	0.0253
B30	EAST BRANDYWINE TWP	936.24	1404.37	0.00	780.20	0.00	136.54	3257.35	11568.11	0.2816
B30	EAST FALLOWFIELD TWP	39.01	117.03	0.00	39.01	0.00	19.51	214.56	11568.11	0.0185

HSPF Subbasin	MS4 Municipality	Residential	Agriculture	Open Land	Forest	Water	Urban	MS4 Total	Subbasin Total	MS4 Ratio
B30	WEST BRADFORD TWP	273.07	214.56	0.00	546.14	0.00	39.01	1072.78	11568.11	0.0927
B30	WEST BRANDYWINE TWP	351.09	1287.34	39.01	507.13	0.00	39.01	2223.58	11568.11	0.1922
B31	EAST MARLBOROUGH TWP	663.17	799.71	78.02	253.57	0.00	19.51	1813.97	5883.50	0.3083
B31	NEWLIN TWP	39.01	468.12	0.00	97.53	0.00	19.51	624.16	5883.50	0.1061
B31	PENNSBURY TWP	58.52	351.09	0.00	136.54	0.00	0.00	546.14	5883.50	0.0928
B31	POCOPSON TWP	780.20	1365.36	0.00	741.19	19.51	78.02	2984.28	5883.50	0.5072
B32	WEST CALN TWP	429.11	1033.77	0.00	1599.42	0.00	58.52	3120.81	2981.99	1.0466
B33	SADSBURY TWP	39.01	19.51	0.00	19.51	0.00	0.00	78.02	5139.05	0.0152
B33	VALLEY TWP	214.56	331.59	19.51	487.63	0.00	175.55	1228.82	5139.05	0.2391
B33	WEST CALN TWP	643.67	1794.47	97.53	1014.26	117.03	117.03	3783.99	5139.05	0.7363
B34	Wilmington, DE	817.01	0.00	360.92	154.42	98.76	1086.4	2517.46	3873.14	0.6500
B34	New Castle Co., DE	152.60	60.27	9.58	222.06	1.52	909.65	1355.68	3873.14	0.3500
B35	WALLACE TWP	58.52	156.04	0.00	351.09	0.00	39.01	604.66	3713.47	0.1628

Note: MS4 Total = total land area in MS4 municipality
Subbasin Total = total land area of HSPF subbasin
MS4 Ratio = MS4 Total / Subbasin Total

Table L-2. Land Use Areas (acres) for MS4 Municipalities in Red Clay Creek Watershed

HSPF Subbasin	MS4 Municipality	Residential	Agriculture	Open Land	Forest	Water	Urban	MS4 Total	Subbasin Total	MS4 Ratio
R01	EAST MARLBOROUGH TWP	565.65	2847.74	39.01	838.72	19.51	156.04	4466.67	6448.43	0.6927
R01	KENNETT SQUARE BORO	136.54	97.53	19.51	0.00	0.00	97.53	351.09	6448.43	0.0544
R01	KENNETT TWP	58.52	78.02	19.51	78.02	0.00	97.53	331.59	6448.43	0.0514
R01	NEW GARDEN TWP	117.03	331.59	0.00	156.04	0.00	97.53	702.18	6448.43	0.1089
R02	KENNETT SQUARE BORO	0.00	19.51	0.00	0.00	0.00	0.00	19.51	4727.00	0.0041
R02	KENNETT TWP	585.15	624.16	0.00	643.67	0.00	0.00	1852.98	4727.00	0.3920
R02	NEW GARDEN TWP	234.06	1891.99	0.00	604.66	0.00	136.54	2867.25	4727.00	0.6066
R03	EAST MARLBOROUGH TWP	546.14	1345.85	234.06	312.08	0.00	156.04	2594.18	6333.99	0.4096
R03	KENNETT SQUARE BORO	175.55	39.01	0.00	58.52	0.00	39.01	312.08	6333.99	0.0493
R03	KENNETT TWP	643.67	1677.44	0.00	916.74	19.51	136.54	3393.89	6333.99	0.5358
R04	KENNETT TWP	195.05	195.05	0.00	292.58	0.00	0.00	682.68	3272.23	0.2086
R04	New Castle Co., DE	1042.15	379.99	257.52	637.52	26.44	245.93	2589.55	3272.23	0.7914
R05	New Castle Co., DE	1153.92	492.06	199.56	1266.25	40.64	200.64	3353.07	3353.07	1.0000
R06	KENNETT TWP	624.16	916.74	19.51	897.23	0.00	97.53	2555.17	4543.71	0.5624
R06	PENNSBURY TWP	78.02	78.02	0.00	58.52	0.00	78.02	292.58	4543.71	0.0644
R06	New Castle Co., DE	313.61	933.77	213.39	184.51	6.01	44.67	1695.96	4543.71	0.3733
R07	New Castle Co., DE	350.82	97.20	39.98	596.30	192.37	66.92	1343.59	1343.59	1.0000
R08	New Castle Co., DE	1268.17	54.61	475.64	464.55	47.93	1132.1	3442.99	3442.99	1.0000
R09	New Castle Co., DE	501.89	0.00	41.68	112.89	4.86	441.99	1103.31	1103.31	1.0000

Note: MS4 Total = total land area in MS4 municipality
Subbasin Total = total land area of HSPF subbasin
MS4 Ratio = MS4 Total / Subbasin Total

Table L-3. Land Use Areas (acres) for MS4 Municipalities in White Clay Creek Watershed

HSPF Subbasin	MS4 Municipality	Residential	Agriculture	Open Land	Forest	Water	Urban	MS4 Total	Subbasin Total	MS4 Ratio
W01	FRANKLIN TWP	331.59	1423.87	0.00	955.75	0.00	136.54	2847.74	6537.83	0.4356
W01	LONDON BRITAIN TWP	78.02	136.54	0.00	214.56	0.00	0.00	429.11	6537.83	0.0656
W01	NEW LONDON TWP	507.13	1014.26	0.00	409.61	0.00	156.04	2087.04	6537.83	0.3192
W01	PENN TWP	175.55	682.68	0.00	214.56	0.00	19.51	1092.29	6537.83	0.1671
W02	LONDON GROVE TWP	468.12	1618.92	19.51	507.13	19.51	19.51	2652.69	6089.44	0.4356

HSPF Subbasin	MS4 Municipality	Residential	Agriculture	Open Land	Forest	Water	Urban	MS4 Total	Subbasin Total	MS4 Ratio
W02	NEW LONDON TWP	39.01	58.52	0.00	58.52	0.00	0.00	156.04	6089.44	0.0256
W02	PENN TWP	273.07	1306.84	0.00	409.61	19.51	39.01	2048.03	6089.44	0.3363
W02	WEST GROVE BORO	156.04	19.51	0.00	0.00	0.00	58.52	234.06	6089.44	0.0384
W03	FRANKLIN TWP	234.06	838.72	0.00	585.15	0.00	0.00	1657.93	4063.37	0.4080
W03	LONDON BRITAIN TWP	448.62	624.16	0.00	682.68	19.51	0.00	1774.96	4063.37	0.4368
W03	LONDON GROVE TWP	195.05	253.57	0.00	195.05	0.00	19.51	663.17	4063.37	0.1632
W04	AVONDALE BORO	39.01	19.51	0.00	19.51	0.00	0.00	78.02	3971.00	0.0196
W04	LONDON GROVE TWP	312.08	2145.56	19.51	916.74	19.51	136.54	3549.93	3971.00	0.8940
W04	WEST GROVE BORO	58.52	39.01	19.51	39.01	0.00	39.01	195.05	3971.00	0.0491
W05	LONDON GROVE TWP	0.00	136.54	0.00	58.52	0.00	0.00	195.05	1705.95	0.1143
W06	AVONDALE BORO	58.52	0.00	0.00	58.52	0.00	0.00	117.03	5484.38	0.0213
W06	LONDON GROVE TWP	39.01	1891.99	0.00	351.09	0.00	39.01	2321.11	5484.38	0.4232
W06	NEW GARDEN TWP	58.52	448.62	136.54	273.07	0.00	97.53	1014.26	5484.38	0.1849
W07	AVONDALE BORO	19.51	58.52	0.00	19.51	0.00	19.51	117.03	877.92	0.1333
W07	NEW GARDEN TWP	136.54	546.14	0.00	97.53	19.51	39.01	838.72	877.92	0.9553
W08	FRANKLIN TWP	117.03	351.09	0.00	136.54	0.00	0.00	604.66	4776.15	0.1266
W08	LONDON GROVE TWP	214.56	624.16	39.01	702.18	0.00	19.51	1599.42	4776.15	0.3349
W08	NEW GARDEN TWP	390.10	1306.84	0.00	780.20	0.00	58.52	2535.66	4776.15	0.5309
W09	FRANKLIN TWP	0.00	19.51	0.00	0.00	0.00	0.00	19.51	4386.93	0.0044
W09	LONDON BRITAIN TWP	273.07	468.12	0.00	643.67	19.51	0.00	1404.37	4386.93	0.3201
W09	NEW GARDEN TWP	546.14	877.73	0.00	604.66	39.01	195.05	2262.59	4386.93	0.5158
W10	LONDON BRITAIN TWP	292.58	429.11	0.00	604.66	0.00	19.51	1345.85	2303.61	0.5842
W10	New Castle Co., DE	208.24	305.42	0.00	430.36	0.00	13.82	957.84	2303.61	0.4158
W11	LONDON BRITAIN TWP	58.52	117.03	0.00	156.04	0.00	19.51	351.09	4175.09	0.0841
W11	Newark, DE	308.85	114.92	122.10	251.39	8.98	111.33	917.56	4175.09	0.2198
W11	New Castle Co., DE	25.21	415.38	175.09	1882.36	24.17	384.21	2906.43	4175.09	0.6961
W12	Newark, DE	470.45	197.52	156.22	125.69	14.36	673.36	1637.60	5610.56	0.2919
W12	New Castle Co., DE	881.65	329.92	391.80	476.03	38.16	1855.4	3972.96	5610.56	0.7081
W13	New Castle Co., DE	92.06	149.15	95.56	152.54	20.96	828.58	1338.85	1338.85	1.0000
W14	New Castle Co., DE	232.26	0.00	473.83	304.83	314.16	859.76	2184.84	2184.84	1.0000
W15	Newark, DE	7.18	0.00	0.00	0.00	0.00	0.00	7.18	2489.61	0.0029
W15	New Castle Co., DE	354.20	734.14	81.03	1050.46	0.00	262.60	2482.43	2489.61	0.9971
W16	New Castle Co., DE	1656.07	357.50	387.82	547.53	0.00	1300.9	4249.78	4249.78	1.0000
W17	KENNETT TWP	19.51	175.55	0.00	19.51	0.00	0.00	214.56	8320.77	0.0258
W17	NEW GARDEN TWP	0.00	58.52	0.00	0.00	0.00	0.00	58.52	8320.77	0.0070
W17	New Castle Co., DE	2847.08	672.52	844.32	952.36	0.03	2731.4	8047.68	8320.77	0.9672

Note: MS4 Total = total land area in MS4 municipality
Subbasin Total = total land area of HSPF subbasin
MS4 Ratio = MS4 Total / Subbasin Total

Table L-4. Land Use Areas (acres) for MS4 Municipalities in Christina River Watershed

HSPF Subbasin	MS4 Municipality	Residential	Agriculture	Open Land	Forest	Water	Urban	MS4 Total	Subbasin Total	MS4 Ratio
C01	Newark, DE	28.73	39.50	12.57	23.34	0.00	168.79	272.93	4288.78	0.0636
C01	New Castle Co., DE	94.94	357.76	90.37	255.93	0.00	38.18	837.18	4288.78	0.1952
C02	Newark, DE	1095.33	0.00	174.18	165.20	0.00	253.18	1687.88	6227.34	0.2710
C02	New Castle Co., DE	27.32	523.32	6.57	258.56	1.32	139.09	956.18	6227.34	0.1535
C03	Newark, DE	360.92	98.76	122.10	122.10	10.77	569.21	1283.87	2903.23	0.4422
C03	New Castle Co., DE	277.57	164.73	95.85	402.58	5.23	673.40	1619.36	2903.23	0.5578

HSPF Subbasin	MS4 Municipality	Residential	Agriculture	Open Land	Forest	Water	Urban	MS4 Total	Subbasin Total	MS4 Ratio
C04	Wilmington, DE	3.59	0.00	1.80	0.00	0.00	1.80	7.18	3443.61	0.0021
C04	New Castle Co., DE	1012.41	48.63	315.16	627.61	8.45	1424.17	3436.43	3443.61	0.9979
C05	Wilmington, DE	333.99	0.00	52.07	30.53	0.00	86.19	502.77	2459.29	0.2044
C05	New Castle Co., DE	181.40	0.00	319.94	183.63	27.03	1244.51	1956.51	2459.29	0.7956
C06	Newark, DE	0.00	0.00	0.00	10.77	0.00	0.00	10.77	5532.47	0.0019
C06	New Castle Co., DE	786.46	817.40	564.42	2025.95	59.89	1037.13	5291.24	5532.47	0.9564
C07	New Castle Co., DE	843.87	344.68	328.54	1398.69	34.25	1127.56	4077.59	4077.59	1.0000
C08	New Castle Co., DE	1716.70	357.44	476.20	1843.67	36.71	2706.49	7137.21	7137.21	1.0000
C09	Newport, DE	48.48	0.00	17.96	0.00	16.16	210.09	292.69	14002.93	0.0209
C09	Wilmington, DE	628.47	0.00	518.93	0.00	254.98	1203.06	2605.44	14002.93	0.1861
C09	New Castle Co., DE	836.12	251.48	2265.00	1746.20	329.18	5676.83	11104.80	14002.93	0.7930

Note: MS4 Total = total land area in MS4 municipality
Subbasin Total = total land area of HSPF subbasin
MS4 Ratio = MS4 Total / Subbasin Total

Appendix M

EPA Bacteria Indicator Tool User's Guide

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EPA Bacterial Indicator Tool

User's Guide

Bacterial Indicator Tool
User's Guide
March 31, 2000

INTRODUCTION

The Bacterial Indicator Tool is a spreadsheet that estimates the bacteria contribution from multiple sources. Currently, the tool is enabled for fecal coliform. However, the tool could be adapted for other bacterial indicators, such as *E. coli*, if the necessary bacteria production information is available. Output from the tool is used as input to WinHSPF and the Hydrological Simulation Program Fortran (HSPF) water quality model within BASINS. The tool estimates the monthly accumulation rate of fecal coliform bacteria on four land uses (cropland, forest, built-up, and pastureland), as well as the asymptotic limit for that accumulation should no washoff occur. The tool also estimates the direct input of fecal coliform bacteria to streams from grazing agricultural animals and failing septic systems. The Bacterial Indicator Tool was developed to provide starting values for model input, however a thorough calibration of the model is still recommended.

The Bacterial Indicator Tool is based on a modeling study of 10 subwatersheds, composed of four land uses (cropland, forest, built-up, and pastureland). BLUE text found throughout the spreadsheet presents valuable information and assumptions. RED text designates values that should be specified by the user. BLACK text usually presents information that is calculated by the spreadsheet or that should not be changed. The tool contains the following worksheets:

Worksheet Name	Purpose
Land Use	Lists the distributions of built-up land, forestland, cropland, and pastureland in up to 10 subwatersheds.
Animals	Lists the number of agricultural animals in each subwatershed (beef cattle, dairy cattle, swine, chickens, horses, sheep, and other [user-defined]), and the densities of wildlife by land use category (ducks, geese, deer, beaver, raccoons, and other [user-defined]).
Manure Application	Calculates the fraction of the annual manure produced that is available for washoff based on the amount applied to cropland and pastureland in each month and the fraction of manure incorporated into the soil (for hog, beef cattle, dairy cattle, horse, and poultry manure).
Grazing	Lists the days spent confined and grazing for beef cattle, horses, sheep, and other. Beef cattle are assumed to have access to streams while grazing.
References	Lists literature and assumed values for manure content, wildlife densities, and built-up fecal coliform accumulation rates. These values are used in calculations in the remaining worksheets.

Worksheet Name	Purpose
Wildlife	Calculates the fecal coliform bacteria produced by wildlife by land use category.
Cropland	Calculates the monthly rate of accumulation of fecal coliform bacteria on cropland from wildlife, hog, cattle, and poultry manure.
Forest	Calculates the rate of accumulation of fecal coliform bacteria on forestland from wildlife.
Built-up	Calculates the rate of accumulation of fecal coliform bacteria on built-up land using literature values.
Pastureland	Calculates the monthly rate of accumulation of fecal coliform bacteria on pastureland from wildlife, cattle, and horse manure, and cattle, horse, sheep, and other grazing.
Cattle in Streams	Calculates the monthly loading and flow rate of fecal coliform bacteria contributed directly to the stream by beef cattle.
Septics	Calculates the monthly loading and flow rate of fecal coliform bacteria from failing septic systems.
ACQOP&SQOLIM (for land uses)	Summarizes the monthly rate of accumulation of fecal coliform bacteria on the four land uses; calculates the build-up limit for each land use. Provides input paramters for HSPF (ACQOP/MON-ACCUM and SQOLIM/MON-SQOLIM).

The following information must be input by the user:

- Land use distribution for each subwatershed (built-up, forest, cropland, and pastureland, including, to the extent possible, the breakout of built-up land into commercial and services, mixed urban or built-up, residential, and transportation/communications/utilities).
- Agricultural animals in each subwatershed
- Wildlife densities for forest, cropland, and pastureland in the study area (built-up land is assumed not to have wildlife)
- Number of septic systems in the study area
- Number of people served by septic systems in the study area
- Failure rate of septic systems in the study area

Default values are supplied for the following inputs, but they should be modified to reflect patterns in the study watershed:

- Fraction of each manure type that is applied each month
- Fraction of each manure type that is incorporated into the soil
- Time spent grazing and confined by agricultural animals (and in stream for beef cattle only)

Literature values are supplied for the following inputs, but they may be replaced with user values if better information is available for the study watershed:

- Animal waste production rates and fecal coliform bacteria content
- Fecal coliform bacteria accumulation rates for built-up land uses
- Raw sewage fecal coliform bacteria content and per capita waste production

The remainder of this document describes the purpose and use of each worksheet within the Bacterial Indicator Tool, as well as the input required by the user (if any). The symbol "**U**" indicates that user input is required in the sheet being described; the symbol " - " indicates that no input is needed.

LAND USE

U	User Input Required

The modeled land uses are derived from the original land uses by reassigning the original categories to the corresponding model categories. Only four categories are considered in this tool: Cropland, Forest, Built-up, and Pastureland. Reassign the categories in your existing land use database, and calculate the acres of each of the four model land use categories within each subwatershed. Enter the values in the appropriate cells on the Land Use sheet. Total acres by subwatershed and land use category will be calculated automatically.

ANIMALS

U	User Input Required

Fecal contributions from the animals listed in this worksheet are used to derive loading estimates for all land uses except for built-up. Only manure from cattle, swine, and poultry is assumed to be collected and applied to cropland. Cattle manure is also assumed to be applied to pastureland. Horse manure is assumed to be collected and applied to pastureland only. Manure from cattle, horses, sheep and "other" agricultural animals is assumed to be contributed to pastureland in proportion to time spent grazing. Wildlife densities are provided for all land uses except built-up and are assumed to be the same in all subwatersheds. An "other" category is provided for both agricultural animals and wildlife to allow the user to include animals that are not already available in the tool.

In the absence of site-specific data, the number of agricultural animals present in each subwatershed can be determined using county-level data from the Census of Agriculture (http://www.nass.usda.gov/census/census97/highlights/ag-state.htm). The total number of agricultural animals can be estimated for each subwatershed based on a ratio of subwatershed-level pastureland to county-level pastureland area. For example, assume Subwatershed 1 is located entirely within County A and that County A contains 1000 acres of pastureland and 200 dairy cows. If Subwatershed 1 contains 100 acres of pastureland, this subwatershed is assigned [(200/1000)*100] = 20 dairy cows. Calculate the number of agricultural animals (dairy and beef cattle, swine, chickens, horses, sheep, and "other") in each subwatershed and enter these values in the appropriate cells on the Animals sheet. Totals by subwatershed and animal type will be calculated automatically.

The densities of wildlife are estimated based on the best available information. It is assumed that no wildlife are present on built-up land and that the densities of wildlife on each of the remaining land use types (forest, cropland and pastureland) are the same across all subwatersheds. Enter the density for each form of wildlife (ducks, geese, deer, beaver, raccoons, and "other") on each land use type in animals per square mile. The wildlife densities per acre will be calculated automatically.

MANURE APPLICATION

U	User Input Required

This sheet contains information regarding the land application of waste produced by agricultural animals in the study area. Application of hog manure, cattle manure, horse manure, and poultry litter is considered. The information is presented based on the monthly variability of waste application. The annual production of manure is calculated and then applied each month using the information in this sheet. It is assumed that cattle manure is applied to both cropland and pastureland using the same method. Hog manure and poultry litter are assumed to be applied only to cropland. Horse manure is assumed to be applied only to pastureland.

For each of the four major manure sources (hogs, cattle, horses, and poultry), specify the fraction of the annual manure produced that is applied each month (January through December) and the fraction of the manure applied that is incorporated into the soil. The fraction of manure available for washoff each month for each type of manure will then be calculated automatically. Note that the equation used to calculate the fraction available for runoff can be updated if necessary.

GRAZING

U	User Input Required

This sheet contains information relevant to cattle, horses, sheep, and "other" animals grazing in the study area. Dairy cattle are assumed to be kept only in feedlots. Therefore, all of their waste is used for manure application (divided between cropland and pastureland). Beef cattle are assumed to be kept in feedlots or allowed to graze (depending on the season). When they are grazing, a certain proportion is assumed to have direct access to streams. The grazing time spent in streams actually represents a combination of the number of animals with stream access and the percent of time these animals spend contributing waste directly to the streams. Beef cattle waste is therefore applied as manure to cropland and pastureland, contributed directly to pastureland, or contributed directly to streams (referred to by the tool as Cattle in Streams). Horses are assumed to be either kept in stables or allowed to graze. Horse waste is therefore either applied as manure to pastureland or contributed directly to pastureland; horse manure is not applied to cropland. Sheep are assumed to be allowed to graze year-round. Sheep waste is therefore contributed only directly to pastureland. The purpose of the “other” animal category is to allow you to define the grazing patterns of an agricultural animal not available in the default information. To use this category, you must be sure to enter the number of “other” animals in each subwatershed (on the Animals sheet) and to specify a fecal coliform bacteria production rate for this animal (on the References sheet). "Other" animal waste is contributed directly to pastureland only while grazing.

For cattle, horses, sheep, and “other,” enter the fraction of time spent confined each month (from 0, never confined, to 1, always confined). The fraction of time and the number of days per year spent grazing will be calculated automatically. For cattle, you should also specify the fraction of time grazing that is spent in streams. The fraction of time grazing spent in pasture will be calculated automatically.

REFERENCES

-	User Input Required

The data from the References sheet are accessed in the remaining worksheets. Fecal coliform production rates for various animals are presented from several sources, and you may select the source you prefer or enter a value of your own in the “Best Professional Judgement” column. The spreadsheet is set up to use the ASAE values by default. If you prefer to use a different source, be sure to change the values in cells B9 through B23 on the References sheet. To use the “other” agricultural and wildlife animal categories, you must provide the number of “other” animals in each subwatershed (on the Animals sheet) and a fecal coliform bacteria production rate for this animal (on the References sheet). The References sheet also contains fecal coliform accumulation rates for five Built-up land use types. These numbers may also be changed if appropriate.

WILDLIFE

-	User Input Required

This sheet calculates the total fecal coliform bacteria produced by wildlife each day per acre of cropland, pastureland, and forest. This calculation is performed by multiplying the density (animals per acre) of each type of wildlife on each land use by the rate of fecal coliform production for that wildlife type (count per animal per day). The number of fecal coliform bacteria produced is then summed across all wildlife types for each land use to obtain a total wildlife fecal coliform production rate (count per acre per day), which will be used in subsequent sheets.

To use the "other" wildlife category, you must be sure to enter the number of "other" animals in each subwatershed (on the Animals sheet) and to specify a fecal coliform bacteria production rate for this animal (on the References sheet). No user input is required on the Wildlife sheet.

CROPLAND

-	User Input Required

This sheet calculates the total fecal coliform bacteria applied to each acre of cropland by month. The sources of fecal coliform bacteria for cropland are wildlife, hog manure application, cattle manure application, and poultry litter application. No user input is required on the cropland sheet. Chickens and hogs are assumed to be confined all of the time, and their manure is applied only to cropland. Dairy cattle are also assumed to be confined all of the time, and their manure is applied to both cropland and pastureland. Beef cattle are assumed to be either kept in feedlots or allowed to graze, depending on the season. When they are grazing, a certain proportion is assumed to have direct access to streams (as specified in the Grazing sheet.) Beef cattle manure is therefore either applied to cropland and pastureland, contributed directly to pastureland during grazing, or contributed directly to streams (referred to by the tool as Cattle in Streams.)

Wildlife
The fecal coliform bacteria produced by wildlife per acre of cropland is determined for each month as follows:

1. The total wildlife population of each subwatershed is calculated (acres of cropland from the Land Use sheet multiplied by the cropland wildlife density from the Wildlife sheet.)
2. The total daily fecal coliform bacteria load generated by that population is calculated (acres of cropland from the Land Use sheet multiplied by the fecal coliform generated per acre of cropland from the Wildlife sheet).

3. The daily per acre accumulation rate of fecal coliform bacteria from wildlife is calculated by dividing the total load generated by the number of acres of cropland in each subwatershed.

Hog Manure

The fecal coliform bacteria from hog manure applied per acre of cropland is determined for each month as follows:

1. The number of hogs in each subwatershed (from the Animals sheet) is multiplied by the daily fecal coliform production rate per hog (from the References sheet) to obtain the daily hog fecal coliform production rate.
2. The daily rate is then multiplied by 365 to obtain the amount of fecal coliform produced by hogs per year.
3. The fecal coliform bacteria available for washoff is then calculated by multiplying the annual fecal coliform produced by the amount applied and available for washoff in each subwatershed in each month (from the hog manure section of the Manure Application sheet).
4. The monthly total is then divided by the number of days in each month to obtain the daily accumulation rate.
5. Finally, the daily accumulation rate is divided by the number of acres of cropland in each subwatershed to obtain the daily per acre load of fecal coliform bacteria from hog manure.

Cattle Manure

The fecal coliform bacteria from cattle manure applied per acre of cropland is determined for each month as follows:

1. The number of dairy and beef cattle in each subwatershed (from the Animals sheet) is multiplied by the daily fecal coliform production rate per dairy and beef cow (from the References sheet) to obtain the daily dairy and beef cattle fecal coliform production rates.
2. The daily dairy fecal coliform production rate is then multiplied by 365 to obtain the amount of fecal coliform produced by dairy cattle and available for application as manure per year. The daily beef fecal coliform production rate is multiplied by 365 minus the days spent grazing (from the cattle section of the Grazing sheet) to obtain the amount of fecal coliform produced by beef cattle and available for application as manure per year. (The fecal coliform bacteria produced by beef cattle while grazing is assumed to be delivered directly to pastureland.) The total fecal coliform load from cattle manure application is the sum of the dairy and beef loads.
3. The fecal coliform bacteria available for washoff is then calculated by multiplying the annual fecal coliform produced by the amount applied and available for washoff in each subwatershed in each month (from the cattle manure section of the Manure Application sheet).
4. The monthly total is then divided by the number of days in each month to obtain the daily accumulation rate.

5. Finally, the daily accumulation rate is divided between cropland and pastureland and the portion applied to cropland is divided by the number of acres of cropland in each subwatershed to obtain the daily per acre load of fecal coliform bacteria from cattle manure.

Poultry Litter

The fecal content of the litter is considered here, despite the fact that litter is the combination of manure and bedding. As such, the fecal coliform bacteria produced by chickens and applied to cropland is estimated from the rate of manure production per chicken and the bacteria content of that manure, rather than from the bacteria content of the combined manure and bedding.

The fecal coliform bacteria from poultry litter applied per acre of cropland is determined for each month as follows:

1. The number of chickens in each subwatershed (from the Animals sheet) is multiplied by the daily fecal coliform production rate per chicken (from the References sheet) to obtain the daily poultry fecal coliform production rate.
2. The daily rate is then multiplied by 365 to obtain the amount of fecal coliform produced by chickens per year.
3. The fecal coliform bacteria available for washoff is then calculated by multiplying the annual fecal coliform produced by the amount applied and available for washoff in each subwatershed in each month (from the poultry litter section of the Manure Application sheet).
4. The monthly total is then divided by the number of days in each month to obtain the daily accumulation rate.
5. Finally, the daily accumulation rate is divided by the number of acres of cropland in each subwatershed to obtain the daily per acre load of fecal coliform bacteria from poultry litter.

The total accumulation rate of fecal coliform bacteria from cropland is calculated as the sum of the accumulation rates from wildlife and hog, cattle, and poultry manure applications.

FOREST

-	User Input Required

The wildlife population is the only fecal coliform contributor to forest considered. No user input is required on the Forest sheet. The fecal coliform bacteria produced by wildlife per acre of forest is determined for each month as follows:

1. The total wildlife population of each subwatershed is calculated (acres of forest from the Land Use sheet multiplied by the forest wildlife density from the Wildlife sheet).

2. The total daily fecal coliform bacteria load generated by that population is calculated (acres of forest from the Land Use sheet multiplied by the fecal coliform generated per acre of forest from the Wildlife sheet).
3. The daily per acre accumulation of fecal coliform bacteria from wildlife is calculated by dividing the total load generated by the number of acres of forest in each subwatershed.

BUILT-UP

U	User Input Required

Because of the lack of animal counts and other specific source information for built-up land, literature values are used. Built-up land is broken out into four categories:

- Commercial and Services
- Mixed Urban or Built-Up
- Residential
- Transportation, Communications and Utilities

1. The percentage breakout of these categories is specified by the user in the Built-up sheet. The acres of each built-up category in each subwatershed are calculated by multiplying the total built-up acres (from the Land Use sheet) by the percentage breakouts specified by the user.
2. A daily per acre fecal coliform bacteria loading rate is calculated for each built-up category using literature values. The loading rates provided in Horner (1992) and presented in the References sheet are applied as follows:

Built-up category	**Fecal coliform loading rate (count per acre per day)**
Commercial and Services	Commercial
Mixed Urban or Built-Up	Average of road, commercial, single-family low-density, single-family high-density, and multifamily residential
Residential	Average of single-family low-density, single-family high-density, and multifamily residential
Transportation, Communications and Utilities	Road

3. A weighted average built-up fecal coliform bacteria accumulation rate is calculated for each subwatershed based on the individual built-up land use categories present and their corresponding accumulation rates.

PASTURELAND

-	User Input Required

This sheet calculates the total fecal coliform bacteria applied to each acre of pastureland by month. The sources of fecal coliform bacteria for pastureland are wildlife, cattle and horse manure application, and beef cattle, horse, sheep, and other grazing. No user input is required on the Pastureland sheet. It is assumed that dairy cattle are confined all of the time and their manure is applied to both cropland and pastureland. Beef cattle are assumed to be kept in feedlots or allowed to graze, depending on the season. When they are grazing, a certain proportion of the cattle is assumed to have direct access to streams (as specified on the Grazing sheet.) Beef cattle manure is therefore applied to cropland and pastureland, contributed directly to pastureland during grazing, or contributed directly to streams (referred to by the tool as Cattle in Streams.) Horse manure that is not deposited in pastureland during grazing is assumed to be collected and applied to pastureland. Sheep and "other" animal manure that is not deposited in pastureland during grazing is assumed to be collected and treated or transported out of the watershed and is tabulated in the last column of the Pastureland sheet (FC collected).

Wildlife

The fecal coliform bacteria produced by wildlife per acre of pastureland is determined for each month as follows:

1. The total wildlife population of each subwatershed is calculated (acres of pastureland from the Land Use sheet multiplied by the pastureland wildlife density from the Wildlife sheet).
2. The total daily fecal coliform bacteria load generated by that population is calculated (acres of pastureland from the Land Use sheet multiplied by the fecal coliform generated per acre of pastureland from the Wildlife sheet).
3. The daily per acre accumulation rate of fecal coliform bacteria from wildlife is calculated by dividing the total load generated by the number of acres of pastureland in each subwatershed.

Cattle Manure

The fecal coliform bacteria from cattle manure applied per acre of pastureland is determined for each month as follows:

1. The number of dairy and beef cattle in each subwatershed (from the Animals sheet) is multiplied by the daily fecal coliform production rate per dairy and beef cow (from the References sheet) to obtain the daily dairy and beef cattle fecal coliform production rates.
2. The daily dairy fecal coliform production rate is then multiplied by 365 days to obtain the annual amount of fecal coliform produced by dairy cattle and available for application as manure. The daily beef fecal coliform production rate is multiplied by 365 days minus the days spent grazing (from the cattle section of the Grazing sheet) to obtain the annual amount of fecal coliform produced by beef cattle and available for application as manure.

(The fecal coliform bacteria produced by beef cattle while grazing is assumed to be delivered directly to pastureland; see below.) The total fecal coliform load from cattle manure application is the sum of the dairy and beef loads.

3. The fecal coliform bacteria available for washoff is then calculated by multiplying the annual fecal coliform produced by the amount applied and available for washoff in each subwatershed in each month (from the cattle manure section of the Manure Application sheet).
4. The monthly total is then divided by the number of days in each month to obtain the daily accumulation rate.
5. Finally, the daily accumulation rate is divided between Cropland and Pastureland and the portion applied to Pastureland is divided by the number of acres of pastureland in each subwatershed to obtain the daily per acre accumulation of fecal coliform bacteria from cattle manure.

Horse Manure
The fecal coliform bacteria from horse manure applied per acre of pastureland is determined for each month as follows:

1. The number of horses in each subwatershed (from the Animals sheet) is multiplied by the daily fecal coliform production rate per horse (from the References sheet) to obtain the daily horse fecal coliform production rate.
2. The daily rate is then multiplied by 365 days minus the days spent grazing (from the horse section of the Grazing sheet) to obtain the amount of fecal coliform produced by horses and available for application as manure per year. (The fecal coliform bacteria produced by horses while grazing is assumed to be delivered directly to pastureland; see below.)
3. The fecal coliform bacteria available for washoff is then calculated by multiplying the annual fecal coliform produced by the amount applied and available for washoff in each subwatershed in each month (from the horse manure section of the Manure Application sheet).
4. The monthly total is then divided by the number of days in each month to obtain the daily accumulation rate.
5. Finally, the daily accumulation rate is divided by the number of acres of pastureland in each subwatershed to obtain the daily per acre accumulation of fecal coliform bacteria from the application of horse manure.

Beef Cattle Grazing
The fecal coliform bacteria from beef cattle manure deposited during grazing per acre of pastureland is determined for each month as follows:

1. The number of beef cattle grazing is calculated by multiplying the number of beef cattle per subwatershed (from the Animals sheet) by the fraction of time spent grazing (from the Grazing sheet).
2. The fecal coliform load delivered directly to pastureland is calculated by multiplying the number of cattle grazing by the fraction of time spent in pasture (as opposed to in

streams, from the Grazing sheet) and by the rate of fecal coliform bacteria production per beef cow (from the References sheet).

3. Finally, the daily grazing beef cattle fecal coliform production is divided by the number of acres of pastureland in each subwatershed to obtain the daily per acre accumulation rate of fecal coliform bacteria from beef cattle grazing.

Horse Grazing

The fecal coliform bacteria from horse manure deposited during grazing per acre of pastureland is determined for each month as follows:

1. The number of horses grazing is calculated by multiplying the number of horses per subwatershed (from the Animals sheet) by the fraction of time spent grazing (from the Grazing sheet).
2. The fecal coliform load delivered directly to Pastureland is calculated by multiplying the number of horses grazing by the rate of fecal coliform bacteria production per horse (from the References sheet).
3. The fecal coliform load in manure collected for application is calculated by subtracting the number of horses grazing from the total number of horses and multiplying by the rate of fecal coliform bacteria production per horse (from the References sheet).
4. Finally, the daily grazing horse fecal coliform production is divided by the number of acres of pastureland in each subwatershed to obtain the daily per acre accumulation rate of fecal coliform bacteria from horse grazing.

Sheep Grazing

The fecal coliform bacteria from sheep manure deposited during grazing per acre of pastureland is determined for each month as follows:

1. The number of sheep grazing is calculated by multiplying the number of sheep per subwatershed (from the Animals sheet) by the fraction of time spent grazing (from the Grazing sheet).
2. The fecal coliform load delivered directly to Pastureland is calculated by multiplying the number of sheep grazing by the rate of fecal coliform bacteria production per sheep (from the References sheet).
3. The fecal coliform load in manure collected for disposal is calculated by subtracting the number of sheep grazing from the total number of sheep and multiplying by the rate of fecal coliform bacteria production per sheep (from the References sheet).
4. Finally, the daily grazing sheep fecal coliform production is divided by the number of acres of pastureland in each subwatershed to obtain the daily per acre accumulation rate of fecal coliform bacteria from sheep grazing.

Other Animal Grazing

The purpose of the “other” animal category is to allow you to define an agricultural animal not available in the default information. To use this category, you must be sure to enter the number of “other” agricultural animals in each subwatershed (on the Animals sheet), to enter the time spent grazing (on the Grazing sheet), and to specify a fecal coliform bacteria production rate (on the References sheet). The fecal coliform bacteria from “other” animal manure deposited during grazing per acre of pastureland is determined for each month as follows:

1. The number of “other” animals grazing is calculated by multiplying the number of “other” animals per subwatershed (from the Animals sheet) by the fraction of time spent grazing (from the Grazing sheet).
2. The fecal coliform load delivered directly to pastureland is calculated by multiplying the number of “other” animals grazing by the rate of fecal coliform bacteria production per “other” animal (from the References sheet).
3. The fecal coliform load in manure collected for disposal is calculated by subtracting the number of “other” animals grazing from the total number of “other” animals and multiplying by the rate of fecal coliform bacteria production per “other” animal (from the References sheet).
4. Finally, the daily grazing “other” animal fecal coliform production is divided by the number of acres of pastureland in each subwatershed to obtain the daily per acre accumulation rate of fecal coliform bacteria from “other” animal grazing.

The total accumulation rate of fecal coliform bacteria from pastureland is calculated as the sum of the accumulation rates from wildlife, cattle and horse manure applications, and beef cattle, horse, sheep and “other” grazing.

CATTLE IN STREAMS

-	User Input Required

This sheet contains information related to the direct contribution of beef cattle fecal coliform bacteria to streams. This contribution can be represented as a point source in HSPF, which requires input of a flow rate (cubic feet per second, or cfs) and a fecal coliform bacteria loading rate (count per hour). No user input is required on this sheet. It is assumed that only beef cattle have access to streams when grazing. The fraction of grazing time spent in streams is specified on the Grazing sheet.

1. The number of beef cattle in streams is calculated by multiplying the total number of beef cattle (from the Animals sheet) by the fraction of time spent grazing and the fraction of grazing time spent in streams (from the Grazing sheet).
2. The fecal coliform bacteria loading rate (count/hr) is calculated by multiplying the number of beef cattle in streams by the fecal coliform production rate per beef cow (from the References sheet.)
3. The beef cattle waste flow rate is calculated by multiplying the number of cattle in streams by the waste production rate per beef cow (from the References sheet) and an assumed beef cattle waste density of 62.4 pounds per cubic foot.

SEPTICS

U	User Input Required

This sheet contains information related to the contribution of failing septic systems to streams. The direct contribution of fecal coliform from septics to a stream can be represented as a point source in the model, which requires input of a flow rate (cfs) and a fecal coliform bacteria loading rate (count/hr).

To estimate the contribution of fecal coliform bacteria from failing septic systems, the number of septic systems, the number of people served by septic systems, and the estimated rate of septic system failure in the study area must be entered. Population and septic tank data can be retrieved from the U.S. Census Bureau web site (http://venus.census.gov/cdrom/lookup). For example, county level populations and septic tank information can be retrieved from this web site as follows:

- Under "Choose a Database to Browse" select STF3A
- On the next screen, click on "Go to level State--County" and choose a State from the list below, and then click on "Submit."
- On the next screen, choose "Retrieve the areas you've selected below" and select a county on the list, and submit.
- Select "Choose TABLES to retrieve" and submit.
- From the list of tables, select "P1" and "H24" and submit
- Select the format for the retrieval (e.g., HTML)
- The information displayed will include a county level summary of population and of housing units with public sewer, septic tank or cesspool, or other.

The estimated rate of septic system failure in the area of interest should be estimated based on local knowledge. From the preceding information, the average number of people served by each septic system, number of failing septic systems, and density of failing septic systems in the study area are calculated.

1. The number of failing septic systems in each subwatershed is calculated by multiplying the total area of each subwatershed (from the Land Use sheet) by the density of failing septic systems.
2. The number of people served by failing septic systems in each subwatershed is calculated by multiplying the number of failing septic systems by the average number of people served by each septic system.
3. The failing septic system flow rate is calculated by multiplying the number of people served by failing septic systems by an assumed daily waste flow of 70 gallons per person.
4. The fecal coliform bacteria loading rate from failing septic systems is calculated by multiplying the failing septic system flow rate by an assumed fecal coliform bacteria

concentration of 10,000 counts per 100 mL of waste flow. Note that any of the assumed values can be updated to represent more appropriate site-specific information.

ACQOP&SQOLIM (FOR LAND USES)

-	User Input Required

This sheet summarizes HSPF input parameter values calculated based on designations made throughout the spreadsheet. It contains values for model inputs ACQOP (or MON-ACCUM if monthly) and SQOLIM (or MON-SQOLIM if monthly). These parameters represent the rate of fecal coliform accumulation and the maximum storage of fecal coliform bacteria on land uses.

1. The values for ACQOP are simply the total fecal coliform bacteria accumulation rates from each land use sheet (Cropland, Pastureland, Forest, and Built-up).
2. The value for SQOLIM is derived using the following die-off equation from Horsley & Whitten (1986):

$N_t = N_0(10^{(-kt)})$ where: N_t = number of fecal coliforms present at time t
N_0 = number of fecal coliforms present at time 0
t = time in days
k = first order die-off rate constant. Typical values for warm months = 0.51/day and for cold months = 0.36/day

In the above equation, N_0 is the count of fecal coliforms applied per acre per day (MON-ACCUM). N_t is the count of fecal coliforms applied on a given day that survive for some number t of days. The maximum buildup of fecal coliform (MON-SQOLIM) is equal to the sum of the fecal coliforms applied on a given day and of the fecal coliforms that were applied on previous days and have survived until that day. When this calculation is done, the maximum buildup is estimated to be approximately 1.5 times the daily buildup rate during warm months (die-off rate of 0.51/day) and 1.8 times the daily buildup rate for colder months (die-off rate of 0.36/day). Warmer months are assumed to be April through September; colder months are October through March. A buildup limit of 1.8 times the daily buildup rate is assumed for nonmonthly varying SQOLIM (Forest and Built-up).

TRANSFERRING DATA FROM THE BACTERIAL INDICATOR TOOL TO WINHSPF

Information contained in three sheets of the Bacterial Indicator Tool can be transferred to WinHSPF. These sheets are Cattle in Streams, Septics, and ACQOP&SQOLIM (for land uses). The information in the Cattle in Streams and Septics sheets are input into the model as point sources. Each sheet contains the fecal coliform loading rate (in count/hr) and flow rate (in cfs) for each subwatershed. The Cattle in Streams loading and flow rates vary monthly, while the septic rates are constant. See "Detailed Functions - Points Sources" of the *WinHSPF Version 2.0 Manual* (USEPA, March 2001) found in the "\basins\docs" folder for detailed instructions on how to incorporate point sources into WinHSPF.

The information contained in the ACQOP&SQOLIM (for land uses) sheet should be input into WinHSPF using the Input Data Editor. See "Detailed Functions - Input Data Editor" of the *WinHSPF Version 2.0 Manual* (USEPA, March 2001) for detailed instructions on using WinHSPF's Input Data Editor. The constant values for forest and built-up land should be input using the *ACQOP* and *SQOLIM* columns in the PERLND\PQUAL\QUAL-INPUT and the IMPLND\IQUAL\QUAL-INPUT tables.

The monthly varying values for cropland and pastureland should be input using the *MON-ACCUM* and *MON-SQOLIM* tables under PERLND\PQUAL\ and IMPLND\IQUAL\.

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Appendix N

Changes in Land Use in the Christina River Basin 1992 - 2002

Table N-1. Current land use areas Christina River Basin (2000 and 2002 data)

WRA LU Classification	Brandywine in PA, 2000, (acre)	Brandywine in DE, 2002, (acre)	Red Clay in PA, 2000, (acre)	Red Clay in DE, 2002, (acre)	White Clay in PA 2000, (acre)	White Clay in DE 2002, (acre)	Christina in PA, 2000, (acre)	Christina in DE 2002, (acre)
Single Family Residential	41838.88	3552.67	4781.82	6032.97	7961.62	10559.90	267.79	12035.13
Multi Family Residential	2905.01	164.58	133.36	118.61	81.01	1257.01	0.00	2355.95
Commercial	3486.32	1098.28	563.53	525.20	546.41	2025.17	10.27	2996.26
Industrial	1327.11	167.92	137.81	14.07	103.98	403.07	0.00	2497.08
Trans / Comm / Utilities	2190.43	337.86	101.47	91.88	375.64	601.33	0.00	3539.63
Mixed / Other Urban Land	0.00	1540.74	0.00	615.96	0.00	732.36	0.00	2927.37
Institutional / Governmental	1806.05	579.67	305.53	167.60	181.31	1113.50	0.00	903.44
Recreational	2603.03	1495.86	453.13	681.99	521.30	1461.98	106.11	1025.10
Agriculture	70991.52	1846.32	9186.41	1595.58	19091.43	2824.70	862.63	2042.08
Rangeland	0.00	87.65	0.00	113.86	0.00	457.60	0.00	857.66
Forestland	56454.42	3333.79	4760.58	3232.52	9351.85	7032.21	198.28	7153.85
Water	2141.95	329.99	131.48	306.30	248.21	334.12	5.58	847.13
Wetlands	5793.42	65.66	528.90	43.97	643.11	735.77	21.63	2286.09
Barren Lands	5793.42	160.30	528.90	12.77	643.11	93.78	21.63	1073.34

Table N-2. Land use areas used in the HSPF models of Christina River Basin (1992 and 1995 data)

WRA LU Classification	Brandywine in PA, 1995, (acre)	Brandywine in DE, 1992, (acre)	Red Clay in PA, 1995, (acre)	Red Clay in DE, 1992, (acre)	White Clay in PA, 1995, (acre)	White Clay in DE, 1995, (acre)	Christina in PA, 1995, (acre)	Christina in DE, 1992, (acre)
Single Family Residential	33537.26	2931.79	3745.05	5486.55	5445.53	9193.45	252.93	10635.66
Multi Family Residential	2000.60	155.14	62.85	100.41	0.00	910.64	0.00	1773.94
Commercial	2010.15	1002.92	281.19	506.64	294.68	1801.82	1.84	2768.37
Industrial	1098.38	140.28	130.77	13.79	65.69	363.96	0.00	2000.80
Trans / Comm / Utilities	3397.05	264.59	109.80	75.42	435.03	357.42	0.00	2869.96
Mixed / Other Urban Land	53.99	2013.02	0.00	934.80	0.00	985.53	0.00	3265.75
Institutional / Governmental	1180.08	505.84	164.17	211.47	102.13	947.42	0.00	720.91
Recreational	1766.37	1758.38	282.55	552.69	190.51	1298.69	0.00	1520.61
Agriculture	79082.10	1956.79	10751.18	1608.63	21265.07	3500.80	994.49	2875.75
Rangeland	0.00	88.23	0.00	115.15	0.00	295.49	0.00	1562.49
Forestland	62178.87	3561.22	5023.78	3559.13	10645.32	8097.56	240.95	8072.03
Water	1971.20	271.04	84.04	264.49	225.56	310.48	3.81	819.56
Wetlands	3354.97	48.03	451.85	28.31	443.94	900.64	0.00	2235.37
Barren Lands	3354.97	49.31	451.85	45.73	443.94	827.48	0.00	1350.96

Table N-3. Land use changes in percent in the Christina River Basin from 1992 to 2002

WRA LU Classification	Brandywine in PA	Brandywine in DE	Red Clay in PA	Red Clay in DE	White Clay in PA	White Clay in DE	Christina in PA	Christina in DE
Single Family Residential	24.75%	21.18%	27.68%	9.96%	46.20%	14.86%	5.88%	13.16%
Multi Family Residential	45.21%	6.08%	112.18%	18.12%	0.00%	38.04%	0.00%	32.81%
Commercial	73.44%	9.51%	100.41%	3.66%	85.43%	12.40%	458.76%	8.23%
Industrial	20.82%	19.70%	5.38%	2.06%	58.27%	10.75%	0.00%	24.80%
Trans / Comm / Utilities	-35.52%	27.69%	-7.59%	21.82%	-13.65%	68.24%	0.00%	23.33%
Mixed / Other Urban Land	-100.00%	-23.46%	0.00%	-34.11%	0.00%	-25.69%	0.00%	-10.36%
Institutional / Governmental	53.05%	14.60%	86.11%	-20.75%	77.53%	17.53%	0.00%	25.32%
Recreational	47.37%	-14.93%	60.37%	23.39%	173.63%	12.57%	0.00%	-32.59%
Agriculture	-10.23%	-5.65%	-14.55%	-0.81%	-10.22%	-19.31%	-13.26%	-28.99%
Rangeland	0.00%	-0.66%	0.00%	-1.12%	0.00%	54.86%	0.00%	-45.11%
Forestland	-9.21%	-6.39%	-5.24%	-9.18%	-12.15%	-13.16%	-17.71%	-11.37%
Water	8.66%	21.75%	56.46%	15.81%	10.05%	7.62%	46.45%	3.36%
Wetlands	72.68%	36.72%	17.05%	55.33%	44.86%	-18.31%	0.00%	2.27%
Barren Lands	72.68%	225.09%	17.05%	-72.08%	44.86%	-88.67%	0.00%	-20.55%